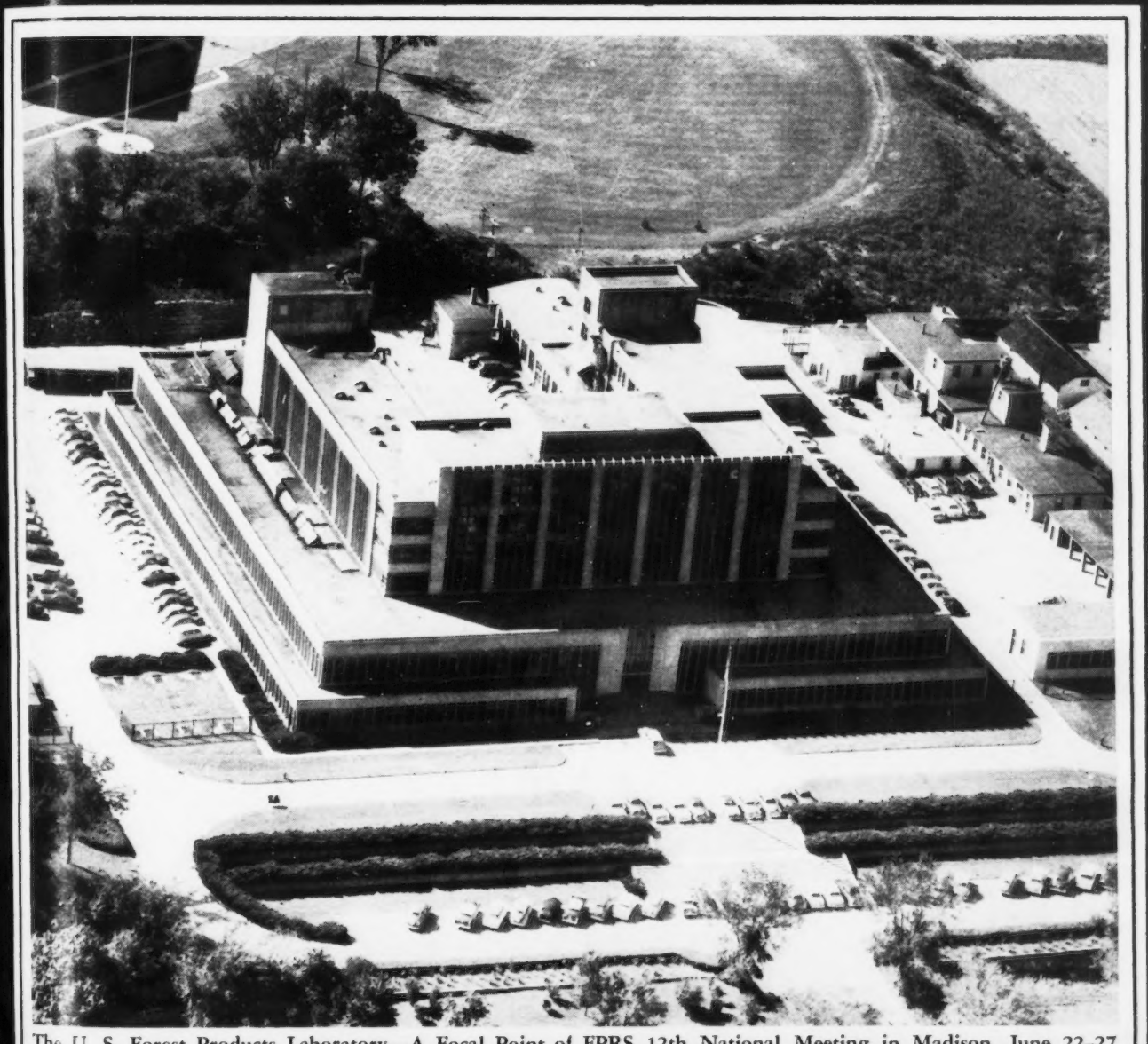
IN THIS ISSUE—
WOOD PRESERVATION

Forest Products Journal



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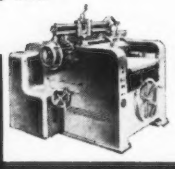

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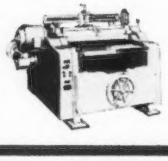

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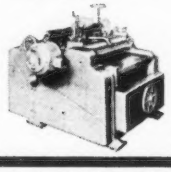

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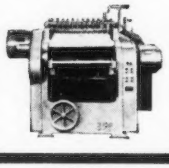

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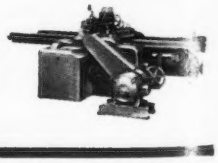

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FOREST PRODUCTS JOURNAL

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Mar. 30–Apr. 1, 1958: Joint ASME, Northeast–Eastern Canadian Section Meeting, Syracuse, N. Y.

April 15–16, 1958: Joint Northwest Wood Products Clinic—FPRS Inland Empire Section Meeting, Spokane, Wash.

April 17–18, 1958: Ohio Valley Section Meeting.

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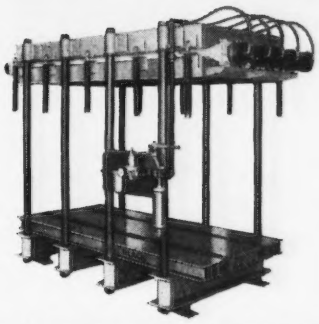

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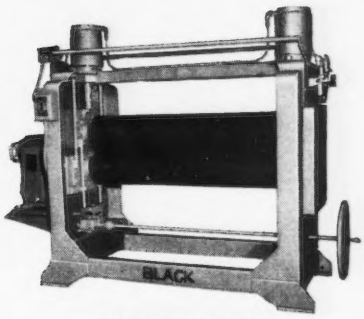

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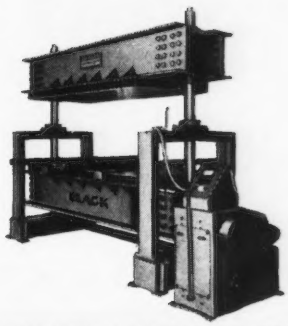

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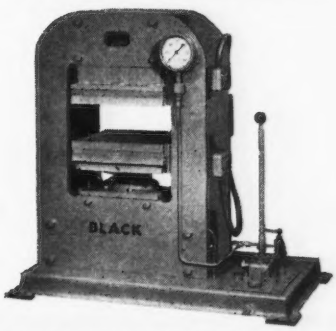

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FPRS NEWS-DIGEST

Volume VIII MARCH, 1958 Number 3

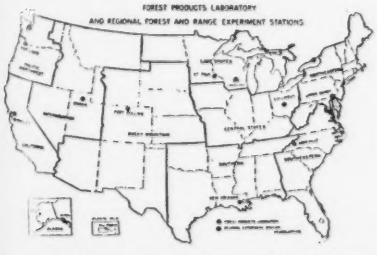
U. S. Forest Products Laboratory Visits to be Feature of Nat'l Meeting, June 22-27

The world's largest institution concerned with the study of wood and wood products, the U. S. Forest Products Laboratory, will provide an important experience for those who attend the FPRS 12th National Meeting in Madison, June 22–27. The meeting will feature a tour of the Laboratory's facilities as well as individual consultations with Laboratory experts by appointment.

Founded in 1910 by the U. S. Dept. of Agriculture, the Laboratory is operated in cooperation with the University of Wisconsin. In 1932, the original Laboratory building was vacated when new, modern facilities were constructed on the campus.

Laboratory Aims

To maintain the status of wood as one of the most important raw materials in the national economy has been one of the major goals of the Laboratory. In this concern, the Laboratory has pioneered the more efficient utilization of the forest by the reduction of processing losses, and by the utilization of residues. Much of the Laboratory's research in past years has directly and indirectly aided in the establishment of integrated operations and fuller utilization practices in the wood products industries.



Forest Utilization Research staffs are maintained at the Calif. Forest & Range Exp. Sta., Berkeley; Central States Forest Exp. Sta., Columbus, Ohio; Intermountain Forest & Range Exp. Sta., Ogden, Utah; Northeastern Forest Exp. Sta., Upper Darby, Pa.; Pacific Northwest Forest & Range Exp. Sta., Portland, Ore.; Rocky Mountain Forest & Range Exp. Sta., Fort Collins, Colo.; Southeastern Forest & Range Exp. Sta., Asheville, N. C.; and Southern Forest & Range Exp. Sta., New Orleans, La.

An important function of the Laboratory is the dissemination of research results through the Forest Utilization Research staff of the U. S. Forest Service, which consists of broadly trained forest products technicians attached to eight of the forest experiment stations throughout the United States. Traveling widely in the territory assigned to them, they advise individuals and industries on wood-using problems. Periodic trips to the Laboratory allow technicians to keep up-to-date on the latest research and to bring back information most desired in their areas.

Another phase of Laboratory activity that aids industry and the use of wood is the cooperative research program, which is operated on a shared-cost basis with industrial firms. In the past, many hundreds of firms have availed themselves of this service.

The Laboratory reports that about 3,000 individuals come to Madison for help on technical problems on wood during a year. Incoming calls on technical problems are estimated at 2,500 per year, in addition to between 35,000 and 40,000 letters that are written by staff members in response to requests for data.

Laboratory Developments

Much of the Laboratory research has materially aided the development of the wood products industries. Some of the early findings include: the discovery of the toxic properties of chlorinated phenols, which led to the development of pentachlorophenol as a wood preservative; the stressed-cover plywood wall panel, which served as a prototype of the later-day prefabricated house panel; the semi-chemical pulping process for the production of paper from hardwoods; and design and fabrication principles for glued laminated structural timbers.

Dr. J. A. Hall, director of the U. S. Forest Products Laboratory.

In recent years, the Laboratory has developed kiln-drying schedules for the principal native wood species. Log grading for the efficient use of the forest crop has been another major contribution. The strength properties of clear wood of 175 leading American woods have been studied, and the information has been disseminated throughout the wood-products industries. Uses for curved plywood and fiberboard containers have been developed. A major contribution still in the development stage is the paper honeycomb core for light, prefabricated wall-panel construction.

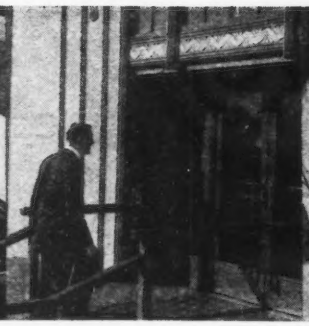
The Laboratory research program is carried out by seven technical divisions, which are aided by two service divisions, Administrative Management and Research Publications and Information.

The Laboratory is under the direction of Dr. J. Alfred Hall, who has been director since 1951. Dr. Hall received his training as a biochemist, and before coming to the Laboratory was director of the Pacific Northwest Forest Experiment Station. He also had served as associate director of the California Forest Experiment Station, and director of the Central States Station.

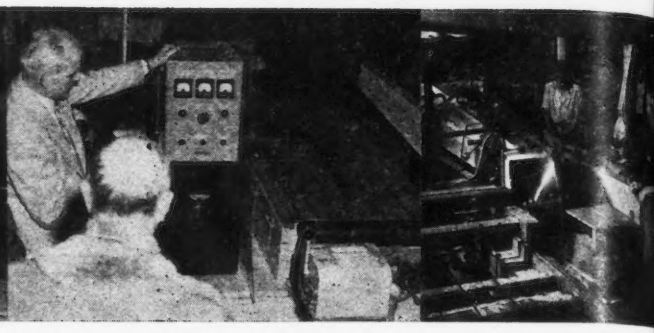
(continued on page 8-A)

"Preview" of the U. S. Forest Product

1 Five hundred to 700 persons are expected to load on busses for the U. S. Forest Products Laboratory tour this June.



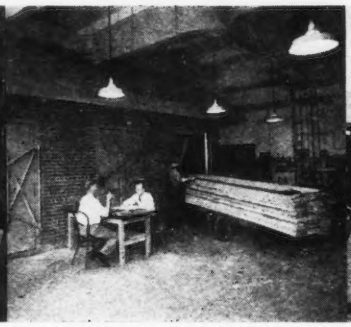
2 Gateway to the two-hour tour of facilities at the government Laboratory located on the west side of Madison.



3 Starting the tour, F. B. Malcolm explains how research aids the small sawmill operator to eliminate waste.

4 The Laboratory's small sawmill rig is used for the study of cutting practices in order to attain better lumber.

9 Particle board is of current interest. Wayne C. Lewis, specialist in this area, will be available for consultation.



10 In the seasoning section, R. C. Rietz, dry kiln specialist, explains the process of removing water from wood.

11 Here, lumber is being loaded in one of the six laboratory dry kilns as part of an experimental test of drying practices.

12 The Physics and Engineering Division studies wood strength properties in relation to making wood a safe, economical material.

17 In the glue section, ways wood can be glued for efficient and attractive utilization are shown.

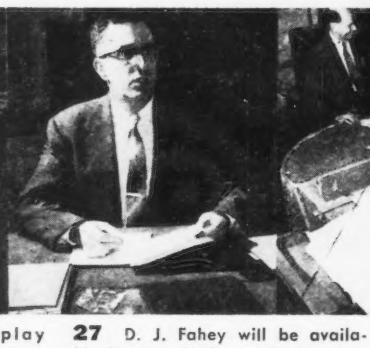
18 Dr. D. Brouse, glue specialist, can be consulted during the FPRS meeting in Madison.

19 Paintability and stability are improved through overlaying knotty lumber with resin-treated papers.

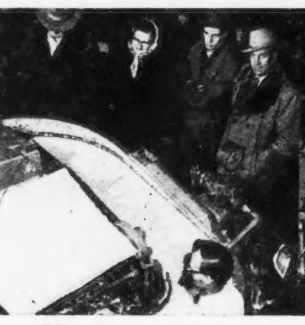
20 M. L. Selbo specializes in laminated members, particularly with preservative-treated wood.

21 Plastic laminates and floors made from hardwood scraps and veneers are studied by B. G. Heebink.

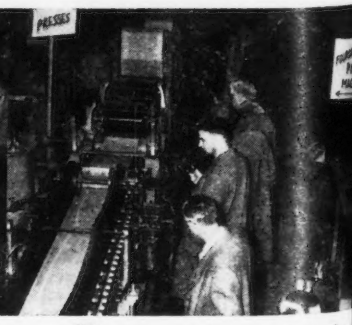
26 Pulp and paper display shows that the average person uses 436 pounds of paper yearly.



27 D. J. Fahey will be available for consultation on paper overlays for plywood and lumber.



28 Beater, one of the many machines used in the pulp and paper mill of the laboratory.

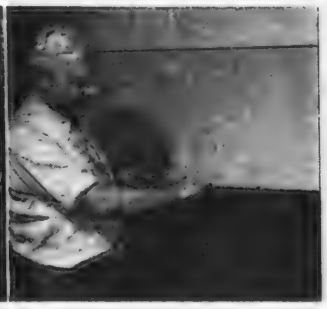


29 Paper machine used for the production of paper and boards from a variety of wood species.

aboratory Tour Planned for FPRS Meeting

5 B. F. Kukachka, wood identification specialist, shown at work. He will be available for consultation during the meeting.

6 How glycerine can be made from wood waste is explained by P. J. Bois in the chemical utilization area.



7 How industrial chemicals, food yeast, and charcoal can be made from scrap waste is shown on display.

8 Dr. A. J. Stamm, wood stabilization specialist, with diffusion board that he helped develop to combat atomic fallout.

13 Two-story wall panel is rigged to a million-ton testing machine in research on design of earthquake resistant structures.

14 In the Wood Chemistry Division, Dr. M. A. Millet checks solutions in the development of new processes.

15 Explanation of methods and equipment for treating and coating wood is shown on display in the Wood Preservation area.

16 D. F. Laughnan checks exposure characteristics of finishes on FPL test fence as part of the Laboratory research program.

22 In the veneer laboratory, modern machinery will be seen, including the veneer lathe shown above.

23 In the Fire Test House, a demonstration is given of how wood can be made fire retardant with chemicals.

24 Push-button drop test for boxes is one means used in studying better design in the packaging laboratory.

25 The large, revolving drum tester used in packaging research will be shown during the tour.

30 In the program of wood preservation, posts are loaded in the pressure cylinder.

31 Dr. Lindgren and Dr. Duncan shown discussing the results of a soil-block test.

32 J. Oscar Blew, known for continuous field studies on the service life of preservatives.

33 Dr. R. H. Baechler, known for development of the double diffusion process.

L. J. MARKWARDT

H. L. MITCHELL

R. P. A. JOHNSON

K. W. KRUGER

E. G. LOCKE

G. H. CHIDESTER

U. S. F. P. L. Visits

(continued from page 5-A)

L. J. Markwardt, Assistant Director of the Laboratory, was for a number of years Chief of what was then the Division of Timber Mechanics. His major research interest is in the field of timber engineering and forest products utilization. He is a former president of the American Society for Testing Materials.

H. L. Mitchell heads the Division of Timber Growth and Utilization Relations, which deals with the relation between growth conditions and wood quality, anatomical structure, and properties, and with the more efficient harvesting and utilization of timber. The Division of Physics and Engineering, under the direction of R. P. A. Johnson, carries out research on wood seasoning and moisture control, and on the strength properties of wood and wood structures.

In the Division of Packaging Research directed by K. W. Kruger, research is carried out with the goal of reducing the amount of material required in containers. In recent years, work on interior packing has been given attention in order to combat external factors such as moisture during shipping or storing.

Dr. R. M. Lindgren directs research in the Division of Wood Preservation, with work emphasizing the study of decay, stain, and organisms that attack wood. Work on developing standards and the promising preservatives in protecting wood is also done.

R. M. LINDGREN

H. O. FLEISCHER

Veneer cutting, wood laminating, plywood and assembly gluing, wood paints and finishes for exterior service, fire retardants, and the study of the durability of glues is covered by the Division of Timber Processing under Dr. Herbert O. Fleischer.

Chemistry, composition, and derived products of wood and wood residues are studied by the Division of Wood Chemistry headed by Dr. Edward G. Locke, a former FPRS president. The Division of Pulp and Paper under G. H. Chidester studies existing pulping and papermaking processes, and works on the development of new and more economical methods with special attention given to hardwoods.

The member of the National Meeting Committee who is arranging the Laboratory visits is John C. Killebrew, information specialist at the Laboratory. As presently planned, the tour will include a survey of Laboratory facilities, starting with the growing and harvesting of wood, through the processing stages where wood is made into semi-finished and finished products, and concluding with special fields such as wood preservation.

During the week-long meeting and especially on Friday, June 27, persons interested will be able to arrange private consultations with Laboratory staff members. An appointment desk will be maintained for this purpose at the headquarters hotel.

PRE-REGISTRATION FORM

TWELFTH ANNUAL MEETING—FOREST PRODUCTS RESEARCH SOCIETY
MADISON, WISCONSIN JUNE 22–27, 1958

Return to: Forest Products Research Society, P.O. Box 2010, University Station, Madison 5, Wisconsin

Name _____
Last First Middle Mrs

Address _____

City _____ State _____

Company or Organization _____

REGISTRATION (Including transportation to Forest Products Laboratory and return)

		Enter Amounts Below
FPRS Member	$ 7.00	$_____
Non-Member	10.00	$_____
Ladies	5.00	$_____
Children Name _____ Age_____		
n/c Name _____ Age_____		
FPRS Official Luncheon, per ticket	3.00	$_____
FPRS Banquet and Paul Bunyan Hour, per ticket	7.00	$_____
Total Enclosed		$_____

Technical Papers Confirmed for National Meeting, June 22-27

Technical program plans are nearing completion for the 12th National Meeting in Madison, June 22–27, according to W. Jeter Eason, FPRS President–Elect and Program Chairman for the meeting. A total of 16 sessions are planned.

The following papers have been confirmed by the authors. Complete program details will be announced in a forthcoming issue.

Keynote Session

Federal Research — V. L. Harper, Ass't Chief, Forest Service, U. S. Dept. of Agriculture, Washington, D. C.

Industry Research — Winton Patnode, Director of Research & Development, Weyerhaeuser Timber Co., Tacoma 1, Wash.

Educational Institution Research—H. L. Shirley, Dean, College of Forestry, State University of New York, Syracuse.

Highlights in the Development of Kiln Drying—Harry D. Tiemann, retired specialist on seasoning from the U. S. Forest Products Lab., Madison, Wis.

Veneer and Plywood

The Effect of High Temperatures on the Strength of Douglas-fir Veneer—P. L. Northcott, Forest Products Laboratories of Canada, Vancouver, B. C.

Wood Preservation

How to Increase the Market for Wood Through Treatment—C. H. Hoffman, Koppers Co., Inc., Pittsburgh, Pa.

Preservative–Water Repellent Treatments for Wooden Packing Boxes—Dr. A. F. Verrall, Chief of Forest Disease Research, Southern Forest Experiment Station, New Orleans, La.

History and Development of Wood Preservation for Millwork in the United States—C. Ormie Lance, Secretary–manager, Nat'l Woodwork Mfrs. Assoc., Chicago, Ill.

Improving Wood's Durability through Chemical Modification—R. H. Baechler, U. S. Forest Products Laboratory, Madison, Wis.

Industry–Education

Training for Research and Development Work for the Wood Industries—B. A. Jayne, Yale School of Forestry, New Haven, Conn., and R. W. Wellwood, University of British Columbia, Vancouver, B. C., Canada

A New Look at the Undergraduate Curriculum in Forest Products—D. B. Richards, John Hill, and Wilbur DeVall, Alabama Polytechnic Institute, Auburn, Ala.

Logging

Radio—Essential Tool of Forestry—Robert W. Olin, Director of Planning, Potlatch Forests, Inc., Lewiston, Idaho.

Integrated Hardwood Logging—C. E.Hein, Chief Forester, Goodman Lumber Division, Calumet & Hecla, Inc., Calumet, Mich.

Employment of Helicopters in Forestry—J. G. Townsend, Manager, Helicopter Division, Spartan Air Service Ltd., Ottawa, Ont., Canada.

Glues and Gluing

Exterior Weathering Studies of Fortified Urea–Resin Glues—R. F. Blomquist and W. Z. Olson, U. S. Forest Products Laboratory, Madison, Wis.

Thermosetting Adhesives from Bark Extracts—Dr. L. H. Bock and Associates, Olympic Research Division, Rayonier, Inc., Shelton, Wash.

Surface Properties of Wood as Related to Joint Strength—J. E. Marian, University of California, Forest Products Laboratory, Richmond.

Industry Uses of an Automatic Machine for the Rapid Evaluation of Plywood Glue Bonds—B. S. Bryant, University of Washington College of Forestry, Seattle.

Quality Control

Organization of a Quality Control Program—Ross Martin, Sears, Roebuck & Co., Chicago, Ill.

Elementary Statistical Quality Control Charts—Edward R. Hansen, Hamilton Mfg. Co., Two Rivers, Wis.

Statistical Quality Control in Logging Cost Control—L. J. Lussier, North Shore Paper Co., Can.

Statistical Control of Grade Yields of Lumber from Hardwood Logs—A. C. Barefoot, and R. M. Carter, North Carolina State College, Raleigh.

Wood Drying

Factors Influencing the Permeability of Softwood During Impregnation and Drying—John P. Krier, School of Forestry, Montana State University, Missoula.

Factors Associated with the Development of Collapse During Kiln Drying of Aspen Lumber—Dr. Arne Kemp, Head, Dept. of Forestry, Stephen F. Austin State College, Nacagdoches, Texas.

Some Aspects of Drying Wood at Temperatures Above 100° C.—Prof. John L. Hill, Alabama Polytechnic Institute, Auburn.

Air Drying of 4/4 Red Oak Flooring Stock in Southern Wisconsin—Edward C. Peck, U. S. Forest Products Laboratory, Madison, Wis.

Roof your Lumber and Increase Your Profits — Wendell Clark and Thomas M. Headlee, Carbondale Forest Research Center, Central States Forest Experiment Station, Carbondale, Illinois.

Air Drying Western Softwoods with Forced Air Circulation—Jack R. Pfeiffer, Oregon Forest Products Research Center, Corvallis.

Operation Predry—Variables in Drying Southern Pine—Louis I. Gaby, Athens-Macon Research Center, Southeastern Forest Experiment Station, Athens, Ga.

Wood Finishing

Quality Control Principles Applied to Inspection of Film Characteristics of Wood Finish — Bruce O. Hallbert, Weyerhaeuser Timber Co., Longview, Washington.

Surface Treatment of Wood Preparatory to Finishing—Armin Elmendorf, Elmendorf Research Inc., Palo Alto, Calif.

The Prefinishing of Plywood with a Vinyl Overlay—W. Jeter Eason, vice president, Nickey Bros., Inc., Memphis, Tenn.

Chemical Utilization

The Production of Torula Yeast from Spent Sulfite Liquor—Jess Holderby, vice president, Lake States Yeast Corp., Rhinelander, Wis.

Microbiological Utilization of Wood Sugars—George Hajny, U. S. Forest Products Laboratory, Madison, Wis.

Alcohol Production from Spent Sulfite Liquor—Carter A. Watson, Technical Director, Puget Sound Pulp & Timber Co., Bellingham, Wash.

The Value of Wood Waste in Promoting Plant Growth—Steward Dunn and Judith D. Emery, Agricultural Experiment Station, Durham, N. H.

Fermentative Action of Isolated Rumen Organisms on Wood Substrates—Don Stranks, Forest Products Laboratories of Canada, Ottawa, Ont.

Preparation and Uses of Sawdust Compost—Prof. Sergius S. Wilde, University of Wisconsin, Madison.

By-Product Utilization from Sulfite Pulping—J. R. Salvesen, Marathon Division, American Can Co., Rothschild, Wis.

Technical and Economic Aspects of Furfural Production from Hardwood—Frederick G. Perry, Jr., Joseph J. Voci, and R. Claire Canty, Arthur D. Little, Inc., Cambridge, Mass.

Newer Activities of National Council for Stream Improvements Re: Air Pollution—Russell O. Blosser, Kalamazoo College, Kalamazoo, Mich.

Steam Pollution Control Activities in Wisconsin—Theodore F. Wisniewski, Director, Wisconsin Commission on Water Pollution, Madison.

Charcoal Briquetting — Paul D. Haigh, vice president, Komarck–Greaves & Co., Chicago, Ill.

General

How to Build Better Wood Houses with Today's Materials—John Reno, Pacific Lumber Co., Chicago, Ill.

Commercial Possibilities of Forests of the Amazon Region — Llewelyn Williams, Randolph, Wis.

Diffusion of Bound Water through Wood Substance—Dr. A. J. Stamm, U. S. Forest Products Laboratory, Madison, Wis.

Steering Committee Proceeds With National Meeting Plans

Finances were reviewed and final organizational details discussed at a meeting of the 1958 National Meeting Steering Committee held Feb. 14 at the Loraine Hotel, according to Robert L. Hiller, general chairman.

To present a preview glimpse of the content of technical papers and to aid discussion at the sessions, the committee decided to print abstracts of papers for the 1958 meeting. These abstracts will be given free of charge to all registrants, Mr. Hiller reported.

In other action, the committee authorized Mr. T. Walter Noble to enter into final arrangements for a professional aquacade of some 16 entertainers to provide entertainment at the FPRS Official Party and Banquet. Mr. L. J. Fitzpatrick reported that initial solicitations for industry sponsorship of the Paul Bunyan Cocktail hour had been sent out.

Mrs. Ralph Simeone presented the Ladies Program, which was accepted by the general committee. It was announced by William Kluender that the Mid-West Section wished to serve as hosts for the get-acquainted hour for registrants on Sunday evening, June 22.

FPRS Directory Announced

An alphabetical directory of FPRS members will soon be released, F. J. Rovsek, executive secretary of the Society, reports. The last directory issued was in February 1957 and was geographic in accordance with Society policy to publish geographic and alphabetical directories in alternate years. Members who desire a copy of the directory may place their request with the national office.

Waste Utilization Shown at Pacific Northwest Tours

Approximately 150 persons attended the Jan. 20–21 annual meeting of the Pacific Northwest Section at Corvallis, Ore., P. L. Northcott, outgoing Section secretary, reported recently. Plans were made for the Section to hold a meeting on "Marketing of Forest Products" on May 5 and 6, with headquarters at the New Washington Hotel, Seattle, Wash.

Field trips opened the January meeting. The Brown Co. fiber pipe plant visited uses old newspaper, kraft pulp, and minor amounts of chemicals to form a sheet of paper. The paper is wound onto a metal tube, dried, and impregnated with a high-melting pitch which is a by-product of the coke industry. The end-product is a light-weight, chemically inert pipe suitable for carrying sewage wastes and corrosive liquids under low pressure. The Chapman–Woods plant also visited uses sawdust shavings and old magazines, with minor amounts of glue and chemicals, to form a building board with planer-shaving core and paper face and back.

The second field trip featured a visit to the hardboard and plywood plants of Cascades Plywood Corp., Lebanon, Oregon.

Of special interest, because of the growing attention to the possibilities of manufacturing overlaid particle boards with strength approaching that of plywood, was the first paper at the Monday afternoon technical session. John S. Fijii, American–Marietta Co., spoke on "The Effects of Overlay Materials on The Flexural Properties of Commercial Particle Board."

The second paper, presented by Raymond Currier, Oregon Forest Research Center, was on "Compression of White–Pocket Douglas–Fir During Hot Pressing." The author described a cooperative study between the Research Center and the Edward Hines Lumber Co., in which three grades of severity of white-pocket wood were used. The amount of compression in plywood made from different grades of white pocket and control veneer, and the average compression after two minutes of pressure, were among values measured.

The third paper was by Dr. Milford D. McKimmey, School of Forestry, Oregon State College, and was entitled "Factors Related to Specific Gravity Variation in Second-Growth Douglas–fir". The data indicated that specific gravity was not influenced by growing site, geographical location, or crown class. The only significant factor found was age from the pith; the specific gravity increased with increasing age from the pith.

Outgoing chairman Wellwood opened the Tuesday morning technical session with an illustrated talk on "Some Impressions of the Forest Industries of Australia and New Zealand". He reviewed the forestry and forest products research being conducted there, and expressed the opinion that the Australians do more applied research than we, but that they have done pre-eminently good fundamental research in relating anatomical characteristics to growing conditions.

William Works, Crown Zellerbach, San Francisco, Calif., presented a paper by himself and H. W. Theurer of the same firm and A. H. Rauch, U. S. Plywood Corp., Seattle, Wash., entitled "Automatic Plastic Filling of Panel Surfaces". The paper described the development of a process to upgrade defective plywood, but indicated that present-day economics are more favorable to other processes, such as conventional patching, so there is no immediate volume application for the process.

James L. Payne, architect of Salem, Ore., spoke on the "Role of Wood in Modern Construction". He drew attention to certain fields where future research is needed, including fire resistance, more realistic acceptance by building codes, and more interesting building boards. He pointed out that information that should be brought to the attention of architects concerning wood were weathering properties, strength, resistance to abrasion, methods of finishing, application details, and samples.

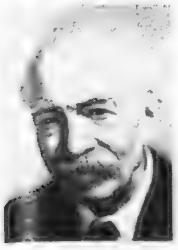
The new laboratory and offices of the Oregon Forest Research Center were toured by registrants on Tuesday afternoon. Demonstrations of many research projects were seen, and members of the staff explained details to the visitors.

In other action, the Section elected new officers for 1958. They are: John Syme, chairman; P. L. Northcott, vice-chairman; William Francis, secretary; Edward Clarke, treasurer; and William West, trustee.

Bark Uses to be Discussed at Northern California Meeting

The annual Northern California Section Spring Meeting will be held May 1 and 2, at the Claremont Hotel, Berkeley, Calif., according to Thomas Shelton, chairman of the Section. Theme of the meeting will be the potential utilization of agricultural and industrial bark. Speakers will cover the current uses of bark and the future market potential of this forest by-product.

Honorary Seasoning Lecture to be Written by Tiemann



H. D. TIEMANN

"High-Lights in the Development of Kiln Drying" is the subject of the Williams Memorial Lecture by Harry D. Tiemann, which will be presented at the 12th National Meeting keynote session, June 23, in Madison, Wis. Mr. Tiemann, who is retired, is an internationally known seasoning specialist.

The lecture was established for the 12th National Meeting by the Moore Dry Kiln Co., Jacksonville, Fla., in memory of Charles J. Williams, a past president of the firm and a leading figure in the wood-drying industry.

Mr. Tiemann, who will write the lecture, began research work 55 years ago and was the first to demonstrate the significance of the fiber saturation point. Associated with the U. S. Forest Products Laboratory from 1910 to 1945, he developed the first practical wood drying kiln in the United States, and is known for his major contributions in the field of the physical properties of wood. He has also done research on the strength of wood and its anatomical structure.

The drying of timber by heat goes as far back as 735 B. C., according to Mr. Tiemann, and "many inventions of 250 years ago embody some or all of the fundamental principles in use today." Mr. Tiemann's lecture will deal with the origin and significance of important features now in use in successful kiln drying of timber that were developed since before the first World War. He played a role in many of these developments.

In his lecture, Mr. Tiemann will consider drying features from two aspects; those which have to do with the physical and mechanical behavior of wood; and those developments which apply to the dry kiln and the means of handling the timber and operation of the drying system, such as apparatus and instruments.

The first lecture of its kind to be presented at a FPRS national meeting, the Williams Memorial Lecture grew out of the desire of the Society to recognize in some honorary way the many research contributions made in the past by persons now retired from active research or business life.

The FPRS Wood Drying Division was the first to explore the possibilities of such an honorarium, and obtained the cooperation of the Moore Dry Kiln Co. in inaugurating the first lecture of this kind within the Society.

FPRS Candidates for National Office Announced

Candidates for FPRS national offices to be elected by mail ballot have been selected, Moss B. Christian, chairman of the 1958 National Nominating Committee, announced this month. Results of the election will be released at the 12th National Meeting, June 22–27, in Madison. Regional Board nominations will be announced later.

W. Jeter Eason, current President-Elect, will automatically become President in June, succeeding Dr. F. H. Kaufert, University of Minnesota School of Forestry. Dr. Kaufert will remain on the Executive Board as Past President.

President–Elect Eason is vice president of Nickey Bros. Inc., and president of the architectural firm of Eason, Anthony, McKinnie, and Cox, designers of the FPRS Executive Office Building. Both firms are located in Memphis, Tenn. A graduate of the Carnegie Institute of Technology, Eason was general chairman of the seventh annual meeting in Memphis in 1953, past chairman of the Mid-South Section, and South–Central Regional Executive Board Member for three years.

W. J. EASON

E. S. HARRAR

Candidates for other offices are:

President Elect: Dr. E. S. Harrar, dean of the Duke University School of Forestry, Durham, N. C., is currently serving as FPRS vice-president. Dr. Harrar served as chairman protem in the organization of the Carolinas–Chesapeake Section, and later as trustee and secretary–treasurer of the Section. From 1953–56 he was Southeastern Regional member of the National Executive Board. A specialist on the structural, physical, and chemical properties of wood, Harrar is a member of the Society of American Foresters, Alpha Xi Sigma, national forestry honorary society, and Sigma Xi, scientific research society.

Vice–President (one to be elected): Raymond H. Berry, vice president, Scott Lumber Co., Shasta County, Calif., or Charles R. Lockard, Chief, Forest Utilization Service, Northeastern Forest Experiment Station, Upper Darby, Pa. Mr. Berry is currently Southwestern Regional Board Member and chairman of the

R. H. BERRY

C. R. LOCKARD

Executive Office Building Fund Drive. He is general chairman of the 1959 National Meeting Committee. Mr. Lockard was general chairman for the 11th National Meeting in Buffalo, N. Y. A charter member of FPRS, Mr. Lockard is a past chairman of the Northeast Section and has served as Northeastern Regional Board Member.

1958 National Nominating Committee (4 to be elected; one more nominee to be announced): Richard F. West, Rutgers University, New Brunswick, N. J.; Alan A. Marra, University of Michigan, Ann Arbor; L. N. Ericksen, California Forest Experiment Station, Berkeley; James R. Roberts, The Celotex Corp., Des Plaines, Ill.; G. Maurice Hill, Drexel Furniture Co., Drexel, N. C.; D. Boyd Richards, Alabama Polytechnic Institute, Auburn; and L. A. Patronsky, Northwest Timber Co., Coeur d'Alene, Idaho.

NOTICE

The Constitution of FPRS provides that "Voting shall not be restricted to the names submitted Twenty-five voting members may file with the Executive Secretary with 30 days after notification of the action of the nominating committees, the name of an eligible candidate for any elective office for which they are entitled to vote. The name of such candidate shall be placed on the ballot. Further, any voting member may vote for any eligible member of his own choice for any elective office by inserting the member's name on the ballot."

Machinery Show to be Part of Redwood Area Logging Meeting

The 20th annual meeting and equipment show of the Redwood Region Logging Conference will be held May 23–24, at Ukiah Calif., according to Emanuel Fritz, secretary–manager of the meeting. The theme of the meeting will be "The Logger: Key Man to Closer Utilization and Permanence". Logging, sawmill machinery, and supplies will be displayed in two buildings, and a large assortment of earth-moving equipment is expected.

Judging Committee Named for Wood Award Competition

J. S. BETHEL

W. R. SMITH

Judges for the 1958 Wood Award Competition have been selected, James S. Bethel, chairman, FPRS Industry–Education Division, announced recently. On the three-man committee are: Walton R. Smith, Southeastern Forest Exp. Sta.; Arthur L. Mottet, International Paper Co.; and Dean Boyd Richards, Alabama Polytechnic Institute.

Among the schools planning entries in this year's competition are the Yale School of Forestry, Michigan State University, Pennsylvania State University, and State University of N. Y. College of Forestry. Eight or nine entries are expected from these schools alone.

Long associated with government work, Smith has been Chief of the Forest Utilization Research Staff at the Southeastern Forest Exp. Sta., Asheville, N. C., since 1952. Arthur L. Mottet, as research director of the International Paper Co., Long–Bell Division, Longview, Wash., plans and supervises research and development in the field of new products. Known for work in the field of wood decay and glued end-joints, D. B. Richards is currently engaged in full-time research at the Alabama Polytechnic Institute, Auburn.

A. L. MOTTET

D. B. RICHARDS

Wood Award competition is open to graduate students in attendance for at least one quarter or semester at any North American university or college between Jan. 1, 1957, and April 30, 1958. The Awards are presented by WOOD AND WOOD PRODUCTS magazine in cooperation with the FPRS Industry–Education Division.

The deadline for submission of tentative titles is rapidly approaching. The complete paper must be submitted in triplicate by May 1, 1958, to the FPRS Executive Secretary, Box 2010, University Station, Madison 5, Wis.

Two cash awards and certificates will be given. The first-place winner will receive $350, and second place, $150, with the awards to be presented at the 12th National Meeting of the Society, June 22–27, 1958. The first-place winner will be invited to present his paper at the Madison meeting.

First-place winner last year was R. L. Youngs, whose paper was entered by the Yale School of Forestry. Charles W. McMillin's paper won second place, and was an entry from the School of Natural Resources, University of Michigan.

Brink to Head New Fiber Research at University of California Lab

D. L. BRINK

A new section in wood fiber and fiber products research will be headed by David L. Brink at the Forest Products Laboratory of the University of California, according to F. E. Dickinson, director of the university laboratory at Richmond.

Brink's major research efforts will be directed toward determining the pulping characteristics of California hardwood and softwood species, to develop or modify chemical pulping processes to reduce water requirements, and to reduce or eliminate stream pollution from pulp-mill effluent. This new area of research was established to find use for the more than 160 million cubic feet of waste residue that is unused each year in California.

Mr. Brink holds a PhD from the University of Minnesota, and has been on the staff of the Weyerhaeuser Timber Co. since 1953 as head of the Organic Chemistry Section of the Central Research Department. His major research at Weyerhaeuser was in the field of bark utilization.

Cellulose Research Conference to be Held April 24 at Syracuse

The newly established Cellulose Research Institute at State University College of Forestry will have its first Cellulose Conference on April 24, according to E. C. Jahn, general chairman of the conference and associate dean of the College of Forestry.

Featured speakers will be Dr. P. H. Hermans, Dutch Institute for Cellulose Research, Netherlands, who will talk on "Recent Contributions of X-ray Low Angle Diffraction to the Investigation of Cellulose Fiber Structure"; and Dr. G. N. Richards, British Rayon Assoc. Laboratories, England, who will speak on "Alkaline Degradation of Cellulose and of Oxycelluloses".

Established in February 1957, the Cellulose Research Institute is an industry-education partnership to provide a central source of fundamental knowledge of cellulose. Dr. J. J. Hermans, director of the Institute, was formerly director of the Laboratory for Inorganic and Physical Chemistry at the University of Leiden, Netherlands. The April conference will be the first of a series of informal meetings concerning fundamental problems of cellulose.

Northeastern Logging Congress Planned April 20–23 at Elmira

A series of discussions on actual working experiences will be featured at the fourth annual Northeastern Logging Congress, April 20–23, at the Mark Twain Hotel, Elmira, N. Y., according to F. C. Simmons, general chairman of the meeting.

"Forest Management and Logging on Small Wood Lots" will be the topic of one session headed by T. W. Lewis, sawmill operator of Roulette, Pa. Another session on "Logging Safety" will be co-sponsored by the wood industries division of the National Safety Council.

K. C. Compton, sawmilling editor of the NORTHEASTERN LOGGER will chairman the "Small Sawmill Clinic", which will include talks on "Choosing and Maintaining a Circular Headsaw", "Purchasing Hardwood Logs on Grade", and "Marketing the Products of the Small Mill."

Hardwood Lumber Grading Short Course Scheduled April 14–18

A hardwood lumber grading short course will be held April 14–18, at the State University College of Forestry at Syracuse, N. Y. Official hardwood lumber grading rules will be covered, and registrants will receive practice in figuring cuttings and grading lumber.

Additional topics to be covered are: growth and structure of wood as they affect grade and identification; hardwood lumber defects; standard hardwood lumber grades; standard inspection; special inspection; and discussion of individual problems.

The course is open to anyone associated with the production, distribution, or use of hardwood lumber. Enrollment will be limited to 20 students, and a registration fee of $35.00 will be charged. Further details are available from the Hardwood Lumber Grading Short Course, Business Office, State University College of Forestry, Syracuse 10, N. Y.

Snyder and Associates Open Second Research Laboratory

F. H. SNYDER

A new research laboratory and main offices have been opened by Francis H. Snyder and Associates, Chemists and Engineers, at New Milford, Conn., Mr. Snyder reported recently. The firm purchased a building that has a floor area of about 8,500 square feet.

Half the new facility is used for pilot-scale research and development, and the balance for research laboratories and offices. Three new processes for the pulping of wood developed by the Snyder firm are reported undergoing final pilot-plant development at the New Milford laboratory.

The firm specializes in the development of highly specialized grades of paper such as oil, water, and chemical filters, moldable and laminating papers, battery separators, lumber and plywood overlay materials, and structural materials made from low-cost fibers and resins. Another field of study is the utilization of wood, sawdust, and bark in the production of organic chemicals.

Founded by Mr. Snyder in 1946, the firm employs 15 technically trained chemists, chemical engineers, plastics specialists, and wood technologists. In addition to the New Milford laboratory, the firm's second facility, a third is planned for completion this year.

New staff members of the Snyder firm are: S. C. Nagel, Eugene Cascone, Charles W. Pimper, Earl Tasman, and Lewis C. Wallace.

New Fire Research Laboratory Established at Kansas City

A fire research laboratory has been established by the Midwest Research Institute to seek new and improved means of preventing, controlling, and fighting fires.

Dr. Buell W. Beadle, manager of the chemistry and chemical engineering division of the institute, reports that fire research is concentrated in the new facility. He stated that the Midwest Research Institute has arranged with the U. S. Fire Protection Engineering Service, Inc., an independent consulting firm of Kansas City, to offer an expanded program in fire research and engineering.

Studies planned for the new center range from the immediate and obvious problems of improving extinguishment techniques and equipment all the way to such long-range problems as fundamental mechanisms of fire.

Photo Progress Report

Monthly Growth of the FPRS Office Building

Laminated posts and beams are being unloaded at the FPRS Executive Building Office site. The posts and beams, estimated at $3,000 worth of material, were donated by Rilco Laminated Products Inc., St. Paul, Minn., and Unit Structures Inc., Peshtigo, Wis.

Officials of the Unit Structures firm are shown at right. From l. to r. they are: J. C. Van Dyke, vice president; Max Haenisch, president; and Maurice Rhude, chief engineer.

Fund Drive Goal In Sight

"We are within striking distance of our goal", R. H. Berry, Executive Building Fund Chairman, stated in reference to contributions received for the building to date. In recent correspondence with the national office, Mr. Berry stated further that the final stage of the drive is underway, and industries that had not yet contributed were being canvassed for contributions. The drive will end April 1.

Furniture Donation

A major furniture donation was made recently by the Hale Co., Inc., of East Arlington, Vermont. The firm offered to donate up to twenty captain's chairs in harmonizing finish for the conference room in the new office building.

Other contributions or pledges in recent weeks were received from Fjellman American Inc., Warren A. Wood; Wood Conversion Foundation; Vilas Furniture Co., Ltd.; Drexel Fund, Inc.; John L. McGinn; and Anderson–Tully Co.

Experimental Chemical Tested for Forest Insect Control

Recent tests show new Sevin experimental insecticide is highly promising for control of insects that attack freshly cut pine wood, Union Carbide Chemicals Co., manufacturer of Sevin reports.

Dr. L. A. Hetrick, College of Agriculture, University of Florida, tested the insecticide by spraying freshly cut slash pine logs to the point of run-off. Logs were left on the ground after treatment. Nine weeks after cutting, treated logs were in sufficiently good condition for milling, while untreated control logs were worthless.

A formulation of Sevin 50% wettable powder was used in the Florida tests. Concentrations of active ingredient ranged from 1½ to 12 pounds per 100 gallons of water spray, but chemical concentration is said to have little effect on length of protection. For all practical purposes, 1½ pounds of Sevin were as good as 12 pounds. Union Carbide reports that Sevin may prove of great value in forest insect control.

BUSINESS NOTES

• Lumber Production—1957

Due to the 1957 slump in home building, lumber production declined 11 per cent in 1957 to the lowest point since 1949. NLMA estimates place total sawmill output for the year at 33,391,000,000 board feet, with softwood (27,494,000,000 feet) down 10 per cent and hardwoods (5,897,000,000 feet) off 16 per cent compared with 1956. Shipments were down eight per cent from 1956.

NLMA Lumber Letter, Feb. 7, 1958

• Lumber Production—December 1957

December's production (2,192,000,000 feet) was 13 per cent below the December 1956 level, but new orders for the month exceeded output by seven per cent, the biggest margin since January 1956. Gross mill stocks at the year's end totaled 9,538,000,000 feet, two per cent below the level at the end of 1956.

NLMA Lumber Letter, Feb. 7, 1958

• Housing

Housing administrator Cole predicted housing starts in 1958 will be higher than last year's level by about 10 per cent, provided there is no worsening of international tensions. He made the prediction in a speech at the 14th annual convention of the National Assoc. of Home Builders.

NLMA Lumber Letter, Jan. 24, 1958

• Forestry

The budget for fiscal 1959 beginning July 1 calls for national forest timber sales of 8.2 billion board feet, valued at $123 million. This is an increase from the fiscal 1958 estimate of seven billion feet, valued at $106.3 million. From lands administered by the Bureau of Land Management, the new budget proposes the sale of 950 million feet of timber with a stumpage value of $21.5 million.

NLMA Lumber Letter, Jan. 24, 1958

• Furniture—1957

The 1957 shipment trend has remained consistently at a level approximately four per cent below 1956. At the year end, both shipments and orders remained unchanged from the November level when 1957 shipments were four per cent less than 1956, which would indicate a volume of shipments of approximately $2,500,000,000. Orders for 1957 were three per cent under 1956.

NAFM statistical report for 1957

New Adhesive Holds 5000 psi

A new adhesive which is said to be unusually strong, versatile, and quick setting, has been developed at Tennessee Eastman Co., Kingsport, Tenn., a division of Eastman Kodak Co., according to the Jan. ASTM BULLETIN.

A single drop on a surface 2 inches in diameter holds 200 pounds in 5 minutes, 5000 pounds in 30 minutes, and 15,000 pounds in 48 hours. It requires no heat, pressure, or solvents. Ultimate steel-to-steel tensile strength is reported at about 5,000 psi in 48 hours. Glass-to-glass bonds are unbreakable in 5 to 15 seconds, steel-to-steel in 20 seconds, wood-to-wood in 5 minutes.

Eastman reports that 1 pound will cover 100 square feet on a smooth, non-porous surface. The adhesive sets within a few seconds after the parts have been pressed together. Most bonds are sufficiently cured within an hour to withstand rough handling.

Short exposure to 212° F. does not materially affect tensile strength; prolonged exposure breaks it down. Eastman 910 resists solvents well.

The adhesive reacts quickly with alkaline substances. It must be kept in closed containers. Shelf life is six months to one year.

Style Show Feature of Nat'l Meeting Ladies Program

One of the many natural formations to be seen at the Cave of the Mounds. A visit to this Wisconsin attraction is planned for the Ladies.

Several tours and excursions are planned for the ladies at the 12th National Meeting in Madison, Mrs. Nancy Simeone, chairman of the Ladies Program Committee, reported recently. The program was planned at a meeting of the committee in February at Mrs. Simeone's home. The Welcoming Reception, sponsored by the Mid-West Section on Sunday evening, June 22, will commence the social activities of the meeting.

As the ladies register, a get-acquainted coffee hour will be held beginning Monday morning at 9:00 am at the Loraine Hotel. A Luncheon and Style Show is planned at the Edgewater Hotel on Monday, June 23, at 12:30 pm, and will be followed by a tour of interesting sites around Madison, including the University of Wisconsin campus. Children may join the ladies for the tour. During the luncheon, a children's activity period with supervisory personnel is planned.

On Tuesday afternoon, ladies may attend a tour of the U. S. Forest Products Laboratory while the children can visit the Madison zoo. A boat trip around Lake Mendota will be featured Wednesday afternoon. The social highlight of the meeting will be the FPRS Official Banquet and Party, Wednesday evening at the Maple Bluff Country Club. Children's accommodations will be available.

The official ladies program will end with an excursion of ladies and children to the Blue Mounds area, and will include visits to the Blue Mounds park, Cave of the Mounds, and Little Norway. A dutch-treat luncheon will take place.

The Ladies Program Committee at a planning session. From l. to r. are Nancy Simeone, chairman; Fern Thompson, vice-chairman; Birdena Rietz; Geraldine Fitzpatrick; Evelyn Johnson; Dorothy Fleischer; Alice Locke; Fern Thompson; Irene Kimball; Betty Jane Rovsek; and Georgia Noble.

New Criteria for Home Livability Cited by U of Illinois Professor

Dimensions are an obsolete means of judging the livability of a house, Prof. William H. Kapple, Univ. of Illinois, told more than 400 builders, architects, and lumber dealers at the January 13th annual short course in residential construction at the University of Illinois. It is furniture size, placement, and the activity space needed by the occupants for living that should be taken into account, he said.

Prof. Kapple was presenting the results of a study concerning sleeping areas based on observations made in the Small Homes Council's space-use experimental house over a period of years. The study was made by a space-use housing research committee that was formed in 1951.

At the two-day meeting, a new type of gable-end, which is said to be economical to construct because it eliminates the need for special roof trusses, was introduced by Prof. Kapple and D. H. Percival, wood technologist. The gable-end consists of a ladder-type panel which is placed over one of the regular roof trusses.

Among the topics covered in the short course were: the effect of span on cost; influence of air-conditioning on design of houses; a new technique for tree stump removal; nail-glued plywood girders; and paper honeycomb uses in residential construction.

A 20-OPENING, 3,650-ton hot press produced by Washington Iron Works, Seattle, Wash., for the new wet process hardboard plant of Johns–Manville Products Corp., Natchez, Miss. The press is of the multi-platen type and is capable of producing 20 panels at a time. It can produce a board up to 4 feet by 16 feet.

Gordon Research Conference on Adhesion Planned August 25–29 in New Hampshire

The "Chemistry of Adhesion" is the topic of one of the Gordon Research Conferences for 1958, and will be held August 25–29 at the New Hampton School, N. H., according to W. George Parks, director of the conferences. G. W. Koehn is chairman, and Alan A. Marra is vice-chairman of the meeting on adhesion. Other conferences will be scheduled from June 9 to August 29.

Held to stimulate research, the conferences have as one of their purposes the dissemination of information that is not realized through the usual channels of publication and scientific meetings. An established rule of each meeting is that all information presented is not to be used without specific authorization of the individual making the contribution, whether in formal presentation or in discussion.

Attendance at each conference will be limited to 100. Additional information is available from W. George Parks, Director, Dept. of Chemistry, University of Rhode Island, Kingston.

Lumber Merchandising Curriculum Begins Sept. at North Carolina

R. M. CARTER

A new four-year course in Lumber and Building Materials Merchandising will begin September 1958, at N. C. State College School of Forestry, Dr. R. J. Preston, dean, School of Forestry, and Prof. R. M. Carter, head, Wood Technology Curriculum, announced recently.

Set up in response to industrial need for highly trained personnel, the course is expected to give graduates a broad background in business methods. Areas that will be covered are administration, sales, distribution, marketing, and the technology of products and materials used in structures and construction work.

This is the first curriculum of its kind to be established in the South, and the fifth in the nation as a whole. Cooperation in setting up the program was received from the Carolina Lumber and Building Supply Association, the National Retail Lumber Dealers Association, and the manufacturers and users of building materials. Further details on the new course may be obtained by writing Prof. R. M. Carter, School of Forestry, N. C. State College, Raleigh.

FPRS Salutes . . .

Men Contributing Time and Efforts for Furtherance of the Society and Wood Industry.

T. W. NOBLE

T. Walter Noble—To see that a "good time is had by all" is the job of Mr. T. Walter Noble, chairman of the Food and Social Committee for the 12th National Meeting in Madison. Arrangements for the traditional FPRS Party and Banquet at the Maple Bluff Country Club in Madison is the largest portion of Mr. Noble's job. He reports that plans are underway for a professional water ballet to provide entertainment at the annual celebration.

A vice president and technical director for Decar Plastic Corp., Middleton, Wis., Mr. Noble is a trustee for the FPRS Mid-West Section. He is a graduate of Wayne State University, where he majored in chemistry. Before his present position, Mr. Noble was president and general manager of Plastics Specialties Inc., Trenton, Mich. He is a member of the American Chemical Society and chairman of the subcommittee on Decorative Laminate/Hardboard Committee of NEMA.

L. J. FITZPATRICK

Lawrence J. Fitzpatrick—One of Wisconsin's leading young businessmen, Mr. L. J. Fitzpatrick is in charge of the Paul Bunyan Hour financial arrangements for the National Meeting in Madison. The customary cocktail hour will precede the FPRS Party and Banquet and will also be held at the Maple Bluff Country Club. Mr. Fitzpatrick reports that 8 firms have already undertaken sponsorship of the Paul Bunyan Hour.

An active member of FPRS, Mr. Fitzpatrick is a past chairman of the Mid-West Section of the Society. President of the J. J. Fitzpatrick Lumber Co., Madison, Wis., he is a 1941 graduate of the University of Wisconsin Law School. Active in civic affairs, Mr. Fitzpatrick is a past National president of the Wisconsin Alumni Association. He is a member of the National Lumber Manufacturers Association and the Wisconsin Manufacturers Association.

NAMES IN THE NEWS

Bernard C. Hartung has been appointed administrative assistant to the executive vice president of the National Lumber Manufacturers Association, Mortimer B. Doyle, it was recently announced. Mr. Hartung was formerly with the California Traffic Safety Foundation.

The Society of American Foresters conferred its Award for Biological Research upon **Harold J. Lutz**, Morris K. Jesup Prof. of Silviculture and Director of Research in Forest Biology at Yale. Prof. Lutz was also named a Fellow of the Society in recognition of his meritorious work.

B. C. HARTUNG

J. M. NELSON, III

Elected President of the National Wooden Box Assoc. at its 59th annual meeting, Feb. 7–8, at Boca Raton, Fla., was **John M. Nelson, III,** vice president of the Nelson Co., Baltimore, Md.

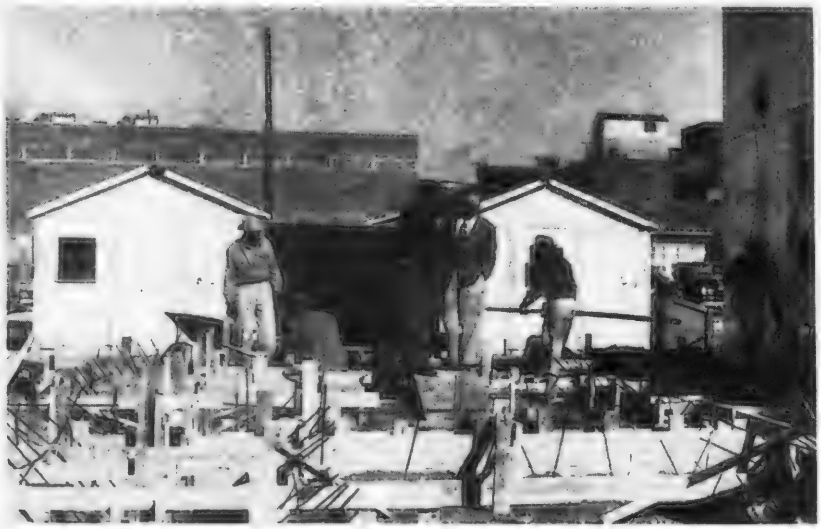
Lester A. Jacobson, Associated Wood Products, Inc., was elected president of the American Institute of Timber Construction at the organization's sixth annual meeting, Jan. 21–23, according to F. J. Hanrahan, executive vice president.

R. W. Wellwood, recently returned from Australia, will be teaching at the Yale School of Forestry until June 1958. He will then return to his position at the University of British Columbia School of Forestry.

A. J. Ewan has been appointed to handle the sales of woodworking machinery for Mattison Machine Works and Greenlee Bros. & Co., Rockford, Ill., the firm recently announced. Mr. Ewan will have charge of sales in southern Indiana, southern Ohio, Kentucky, and West Virginia.

Named vice president of the Armstrong Forest Co., woodlands subsidiary of New York & Pennsylvania Co., is **Arthur L. Bennett.** Bennett was manager of the Dept. of Woodland Operation prior to his current appointment.

THIRTY EXECUTIVES of the Edward Hines Lumber Co. who attended a training demonstration on lumber and allied products at the U. S. Forest Products Lab., Jan. 27–30. Topics covered included identification of woods, essential facts about moisture and wood, wood preservation, good and poor construction practices, chemical utilization of wood, new glued wood products, and painting and finishing characteristics of wood. All speakers were research and engineering specialists.



KENNETH G. CHESLEY, Director of Research, Crossett Co., discusses expansion plans of the firm's research laboratory with the job superintendent. A $200,000 expenditure will cover building and furnishing costs of the new areas that will enlarge the existing laboratory about 60 per cent and include office space, larger laboratory, and paper product pilot-plant facilities. A $300,000 building program is also planned to double charcoal briquet production capacity at Crossett Chemical Co. Completion of the laboratory expansion is expected this spring.

Ronald S. Gale has recently joined the Vermont Bureau of Industrial Research, John M. Sayward, director, has announced. Mr. Gale, experienced in wood technology, has worked as a consultant for wood industries.

See page 38–A for
New Products–Literature
and New Publications

EMPLOYMENT SERVICE

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E–306—High caliber salesman to sell modern sawmill machinery for nationally known west coast manufacturer. Sawmill machinery sales experience preferred. Extensive travelling required. (Mar.)

E–307—Field work and sales position available at Mid-west adhesives firm. Sales experience not required. Will involve travel. State background in woodworking industry and salary desired. (Mar.)

E–308—Research chemist or chemical engineer wanted to head small, West Coast research group. Part of a national, multi-unit research and development organization. Mill or laboratory experience in paper, pulp, or other wood fiber utilization field desirable. (Apr.)

Employment Wanted

No. 457—Position desired in wood products organization in Canada. Interested in product development, plant engineering, production and research. Holds B.S. in Wood Utilization, has one year graduate study and will receive B.S. in Civil Engineering in June 1958. (Mar.)

No. 458—Executive and manager with a 37-year background in logging, production, preservation, accounting, sales, research, development and use of forest products desires position where ability, training and experience are needed. Available on short notice. (Mar.)

No. 459—Position desired in production, sales, management, or research. Will have B. S. in Wood Utilization from Penn State in June. Sound preparation in basic engineering. Research experience in marketing of forest products. Will locate anywhere. (Apr.)

No. 461—Training and educated in forest management, and administration, research in forest utilization, management and economics. Can program research problems for and operate computational machines. Experienced as chemist. (Apr.)

No. 464—Position in hardwood manufacturing or wholesale distribution work desired. Experienced in hardwood sales, manufacturing techniques, kiln operation and grading. Holds B.S. in Wood Technology. (Apr.)

FPRS Forest Products Journal

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Pentachlorophenol and Heavy Petroleum for the Preservative Treatment of Railway Crossties[1]

G. E. OLSON, F. J. MEYER, AND R. M. GOOCH

Technical Service and Development Dep't.; Group Leader, Biochemical Research Dept.; and Chemical Engineer, Biochemical Research Dep't., Dow Chemical Co., Midland, Mich.

The combination of the beneficial weathering characteristics of heavy petroleum oil and the increased effectiveness of pentachlorophenol in this oil presents a sound, economical approach to the treatment of railway crossties. Data show that the penta concentration can be reduced from the traditional five per cent, and still maintain a high degree of preservative effectiveness.

RAILROADS HAVE BEEN INTERESTED in the possibilities of using pentachlorophenol in heavy petroleum for the treatment of crossties for two decades. At least a dozen major railroads have test tracks with pentachlorophenol-treated crossties, some of which are nearly 20 years old. Railroads located in petroleum-producing regions are especially interested in the larger scale use of petroleum from the standpoint of economics. Currently an attempt is being made to relate past practice to the use of pentachlorophenol as the preservative and a heavy petroleum as the preservative carrier and anti-weathering agent.

Shortly after the turn of the century, several railroads pioneered the practice of extending creosote with petroleum or coal tar for the preservative treatment of crossties. This trend grew rapidly, and in a few decades the use of either mixtures of creosote and coal tar or creosote and petroleum for tie treatment was standard practice, for most of the nation's leading railroads. Hunt and Garratt (12)[2] state that the coal tar or the petroleum is added primarily to reduce the cost of the preservative. Another consideration, which makes the use of these mixtures attractive, they indicate, is the beneficial effect of the heavy bodied tar or petroleum on the weathering of the ties in the track. Burton (4) reports that the coal tar tends to give the tie a protective coating. Blair (1) mentions the use of petroleum with creosote as an aid in minimizing checking and splitting of ties under use conditions. The constantly increasing average service life of crossties is an indication of the success of this approach to the crosstie problem.

Laboratory and field data published during the past two decades show the high degree of effectiveness and lasting quality of pentachlorophenol as a wood preservative. These laboratory and field data led to the acceptance of pentachlorophenol in 1948 as a standard preservative of the American Wood Preservers Association and more recently, The American Railway Engineering Association. A standard for the petroleum carrier of the pentachlorophenol also was adopted by both Associations. The test data also supported the use of 5 per cent pentachlorophenol in the petroleum and this consideration is suggested in many different specifications.[3]

In a large number of both laboratory and field tests, standard pentachlorophenol treatments were included with standard creosote treatments for

[1] Presented at Session XI, Wood Preservation, of the Eleventh National Meeting of the FPRS, held June 23-28, 1957, in Buffalo, New York.

The Authors: G. E. Olson was a member of Technical Development Sales and Dowicide Sales Departments before he took his present position with Dow. Olson is a charter member of FPRS.

Fred Meyer holds a BS in chemistry from the University of Michigan. He joined Dow in 1938, and has been active in industrial wood preservation.

R. M. Gooch holds a BS in chemical engineering from the U. of Michigan, and joined Dow in 1946. He has been working in wood preservation since 1947.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

[3] For example "The Manual of Recommended Practice" of the American Wood-Preservers' Association, Specification C1-56, Paragraph 3.12 "Oil-Borne Preservatives" reads in part as follows: "Unless otherwise specified, the concentration of pentachlorophenol in the treating solution shall be between 4.5 and 5.5 per cent, by weight; the petroleum shall meet the requirements of standard P9 for heavy solvent".

Fig. 1.—Test track of penta-treated oak crossties in southeastern United States after five years of exposure. Ties were treated to a retention of 6 pounds per cubic foot of wood, with 2 per cent of penta in a heavy petroleum oil.

comparative purposes. A review of these tests shows that the pentachlorophenol-petroleum treatments compare very well with the standard creosote treatments on a serviceability basis. Furthermore, laboratory soil-block tests point to an equal or somewhat greater effectiveness (5, 6, 7, 8, 9, 10) of the 5 per cent pentachlorophenol in petroleum. As a result, for some years authorities have looked on 5 per cent pentachlorophenol in petroleum and unextended creosote as alternate preservatives for the treatment of wood.

With this acceptance, the concept of extending creosote with coal tar or petroleum for crosstie treatment has been applied to 5 per cent pentachlorophenol petroleum solutions. In short, this would suggest reducing the pentachlorophenol concentration. For example, the use of a 2.5 per cent solution of pentachlorophenol would be consistent with the past practice of railroads that have used a 50 per cent creosote–50 per cent petroleum mixture. It is important to point out, however, that the pentachlorophenol carrier must be selected for physical properties that will give the desired weathering characteristics when the tie is placed in the track, as well as the desired handling and treating characteristics in the plant.

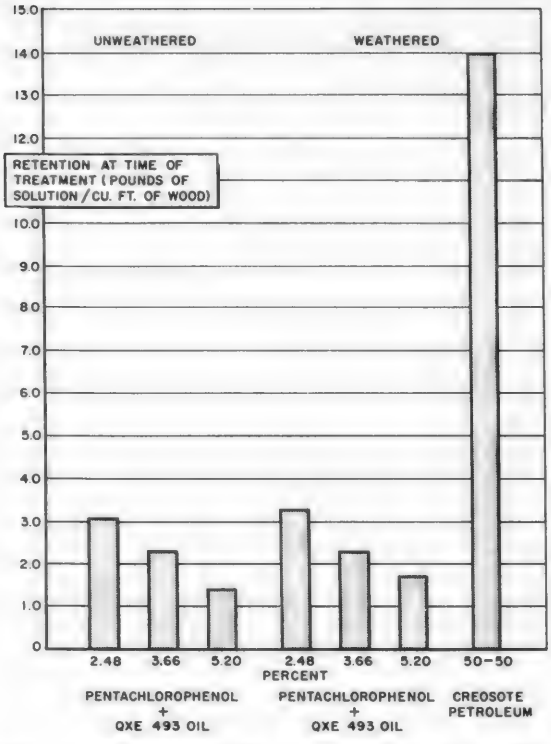

Fig. 1.—Soil-block thresholds for pentachlorophenol—QXE 493 oil solutions and a 50–50 creosote—petroleum solution against *Lenzites trabea* (Madison 617).

Two investigations suggest that a concentration of pentachlorophenol less than 5 per cent may be used. The American Wood-Preservers' Association Committee on Preservatives in their report (14) before the annual meeting of the Association in 1947 presented interesting data on the testing of treated ¾- by ¾-inch southern pine sapwood stakes in Alabama and South Carolina. Stakes given an 8.8 pound per cubic foot treatment with a 2.4 per cent penthachlorophenol-petroleum solution were exposed in a test plot along with stakes containing 7.0 pounds per cubic foot of a 50–50 creosote-petroleum. The 2.4 per cent pentachlorophenol treatment showed results that were significantly better than those for the creosote-petroleum treatment after nine years of exposure.

A second test (3) at Gulfport, Mississippi, started in 1936 by the United States Forest Products Laboratory, includes approximately 100 southern yellow pine posts treated with 5 per cent pentachlorophenol in crank case oil, and 100 posts treated with 3 per cent pentachlorophenol in crank case oil to an average retention of about 6 pounds per cubic foot. The test also includes a similar number of posts treated to approximately the same retention with 50 per cent creosote–50 per cent crank case oil as well as 100 per cent creosote. The 3 per cent pentachlorophenol-petroleum treatment is showing better serviceability than the creosote-crank case oil, and compares favorably with the 5 per cent pentachlorophenol and the 100 per cent creosote treatments after 20 years of exposure.[4]

Laboratory Tests

Work in two separate laboratories on the effectiveness of pentachlorophenol at concentrations of less than 5 per cent was initiated to further explore the possibilities indicated by the test plot results. Experiments by Duncan and Richards (9) to determine the threshold[5] retentions by the soil-block test demonstrated that a 5 per cent solution of pentachlorophenol in 101-E oil[6] diluted to 4, 3, 2, and 1 per cent with a tie-treating petroleum decreased in effectiveness, in a manner similar to that of creosote mixed with 20, 40, 60, and 80 parts of the same petroleum. The threshold retention data also indicated higher effectiveness for the pentachlorophenol dilutions when compared with similar creosote dilutions. In addition, a comparison of the 3 per cent pentachlorophenol solutions and the 60 per cent creosote—40 per cent petroleum solution with the 60 per cent creosote–40 per cent coal-tar solution showed the creosote–tar solution to be between the pentachlorophenol and creosote–petroleum in effectiveness.

Active interest expressed on the part of one large railroad led to further laboratory soil-block tests by The Dow Chemical Company. The railway was interested in comparative data on the effectiveness of pentachlorophenol in an oil considered suitable for crosstie preservation and a creosote-petroleum solution currently in use by this railroad. An experiment was set up to determine the preservative effectiveness of 2.50, 3.75, and 5.00 per cent pentachlorophenol in QXE 493 oil[7], and 50–50 creosote petroleum.

The data from the soil-block tests of both weathered and unweathered pentachlorophenol treated blocks and the weathered creosote-tie oil blocks were used to calculate the threshold values. The results are shown in Fig. 2. The threshold for the weathered ties with 50–50 creosote-petroleum

[4] At the time of this report, the posts had last been inspected in late 1956. They were again inspected in late 1957 (a report has been issued by the Laboratory) as a continuing project.

[5] The threshold retention is defined as the lowest retention that inhibits decay.

[6] A heavy gas oil (Mid-United States) with the following characteristics:

Specific gravity	1.010
Flash point (PMCC)	290° F.
Viscosity (SUS 100° F.)	104
IBP	580° F.
50%	680° F.
85%	752° F.

[7] The QXE 493 oil is a high distilling ... high wax content. Its distillation range ... as follows:

IBP	39[8]
20%	47[8]
95[8]	648

[8] Distilled under vacuum (25 mm press ...).

Fig. 2.—Technician inspecting treated ¾ by ¾ by 18 inch stakes in a test plot located in southern United States. Stake tests have helped establish the desirability of using concentrations of pentachlorophenol in the 2 to 3 per cent range in a heavy petroleum oil.

treatment was 14 pounds of solution per cubic foot of wood against *Lenzites trabea* (Madison 617), compared with a threshold of 3.1 pounds per cubic foot for the weathered ties with 2.48 per cent pentachlorophenol solution against the same fungus. Thus, the data not only support the concept of reduced pentachlorophenol concentration but also indicate a higher degree of preservative effectiveness than that given by the creosote-petroleum solution. It should be pointed out as a general observation, however, that creosote-petroleum solutions seem to perform better in service than would be indicated by the threshold values frequently obtained in soil-block tests. No explanation of this observation has been offered other than the assumption that the conditions of the soil-block test are possibly more severe than the conditions normally encountered for crossties in track.

Under the conditions of this test, the pentachlorophenol threshold appeared to be independent of the ratio of pentachlorophenol to QXE 493 oil in the various solutions, which suggested that the oil did not add to the actual effectiveness of the treatments. Furthermore, the lack of any great difference between weathered and nonweathered specimens suggested that the high-distilling oil very effectively inhibited the loss of pentachlorophenol during the weathering cycle.

Test Plot Investigation

A stake test by Dow followed the work by Duncan and Richards. (9) The test, started in 1950, was an attempt to duplicate as nearly as practical the soil-block test work by Duncan and Richards using the same dilutions of creosote and the same reduced concentrations of pentachlorophenol in petroleum. Stakes three-quarters by three-quarters by eighteen inches were pressure treated, installed, and inspected annually in accordance with the American Wood-Preservers' Association Standards. (15) Ten stakes for each treatment with eight pounds retention per cubic foot were selected for installation at two test plots.

The seven-year results of this test given in Table I give further support to the concept that the 5 per cent pentachlorophenol-petroleum can be extended in the same manner that creosote has been extended in the past. In addition, the figures show some correlation with the soil-block thresholds reported by Duncan and Richards and included with the data in Table I. Moreover, the data in Table I indicate that the conditions of the stake test may more nearly approach actual service conditions, because the various creosote-petroleum treatments are performing in a manner that could be expected from past performance in track.

It may be noted from Table I that the 101-E oil control also gave good results in spite of the fact that it did not have any toxicity as indicated by the threshold value. Past test-plot experience with certain oil controls indicates that they are serviceable up for a time, and then all fail within a relatively short period of one or two years.

Test Ties in Track

A cooperative test program between a group of ten leading railroads and The Dow Chemical Company was started in 1952 as a follow through of the work by Duncan and Richards and the previously reported stake test. Each railroad shippel 500 crossties to

Table 1.—COMPARISON OF THE SERVICEABILITY OF ¾ BY ¾ BY 18 INCH STAKES AFTER SEVEN YEARS OF FIELD EXPOSURE AND SOIL BLOCK TEST THRESHOLD VALUES

Treatment	Threshold[4]		Location			
			Lake Jackson, Texas		Bogalusa, Louisiana	
	Unweathered lb./cu. ft.	Weathered lb./cu. ft.	Per cent serviceability[6]	Number removed	Per cent serviceability[6]	Number removed
20% 201-E oil[2]–80% Seguro[3] oil (1% Penta)	>33.0	>34.0	0	10	21	7
40% 201-E oil[2]–60% Seguro[3] oil (2% Penta)	17.0	17.5	21	4	66	1
60% 201-E oil[2]–40% Seguro[3] oil (3% Penta)	6.2	6.5	57	1	72	0
80% 201-E oil[2]–20% Seguro[3] oil (4% Penta)	4.0	4.1	64	0	73	0
100% 201-E oil[2] (5% Penta)	2.0	2.2	67	0	73	0
20% Creosote–80% Seguro oil	>34.0	>35.0	0	10	32	5
40% Creosote–60% Seguro oil	30.0	>33.0	16	7	42	3
60% Creosote–40% Seguro oil	15.5	20.0	27	3	63	1
80% Creosote–20% Seguro oil	10.0	13.0	32	5	70	0
100% Creosote	6.4	8.1	44	2	70	0
60% Creosote–40% Coal tar	6.5	8.2	58	1	70	0
101-E oil	>38.0		58	1	63	1
Seguro oil	>32.0		0	10	0	10
Untreated control[5]			0	10	0	10

Indicates per cent by volume.
201-E is 101-E oil containing 5% pentachlorophenol; for oil characteristics see footnote No. 6.
Seguro petroleum is a commercially used oil for blending with creosote for crosstie treatment.
From Duncan and Richards (9)
Average service life of one year.
Based on American Wood Preservers Association (15) rating system according to the log base scale. One hundred per cent indicates perfect condition.

the treating plant of the Joslyn Manufacturing and Supply Company at Franklin Park, Illinois. Eight railroads shipped mixed oak and two railroads shipped Pacific Coast Douglas-fir ties. Each participating railroad prepared the ties for treatment according to their specific requirements for adzing, boring, and seasoning prior to shipment to the Joslyn plant.

Five hundred ties for each railroad were pressure treated, 100 with 101-E oil alone, and 100 with 2, 3, 4, and 5 per cent of pentachlorophenol in 101-E oil. After treatment, the ties were shipped back to the individual railroads for installation in test track. The test sections of track are located in widely scattered sections of the United States.

The five-year inspection of these ties is being completed. To date, no significant conclusions can be drawn except that the pentachlorophenol ties are holding up well.

Importance of the Oil Carrier

A survey of the literature makes the use of the heavy petroleum with the pentachlorophenol look very attractive. Meyer and Gooch (13) conclude that, in general, the higher the distillation range of the pentachlorophenol carrier, the better the performance of the treated wood. The data assembled from stake tests (2) cited by Meyer and Gooch and conducted by the Forest Products Laboratory is interesting, when the relative performance of creosote and pentachlorophenol in heavy petroleum is considered. This comparison can be made by referring back to the Forest Products Laboratory Report No. 1761 (2), which shows several high-boiling pentachlorophenol solutions to be performing better than creosote after eight years of exposure. The stakes are 2 by 4 by 18 inches, treated to a four pound per cubic foot retention of the various pentachlorophenol solutions and heavy-residue creosote. Duncan points out in a recent publication (11) that pentachlorophenol in the higher boiling fractions of a given oil has greater permanence than when incorporated with either the lower boiling fractions of the same oil or with the oil itself. Thus, not only should the heavy oil give the desired characteristics for weathering, but it also should enhance the preservative qualities of the treatment.

Economics and Acceptance

With the above type of data available, railroads are investigating the principle of using pentachlorophenol at concentrations of less than 5 per cent in a heavy bodied petroleum for crosstie treatment in lieu of treatments cut back with coal tar or petroleum oil. Because the treating solution contains only a small percentage of pentachlorophenol with the bulk being petroleum, the economics are especially favorable in petroleum-producing regions. Several railroads that have treated crossties with pentachlorophenol on a large scale have substantiated this. These treatments have been with either 5 per cent or reduced concentrations of pentachlorophenol in a suitable crosstie oil.

One railroad, after thorough investigation, has accepted the principle of using pentachlorophenol at concentrations less than 5 per cent in a heavy-bodied petroleum suitable for crosstie treatment. The economics in this instance are especially favorable for the pentachlorophenol-petroleum treatment because the treating plant is centrally located in a petroleum-producing region and close to a large refinery.

Another railroad installed several thousand pentachlorophenol-treated ties a number of years ago. These ties were treated with 50 per cent of a residium oil and 50 per cent light oil as the carrier for the pentachlorophenol. At a recent inspection, the pentachlorophenol-treated ties were no different from their regular treatment after 15 years in track. As a result, this railroad is giving close study to the use of pentachlorophenol and a heavy bodied petroleum for crosstie treatment on a commercial scale.

Summary

The combination of the beneficial weathering characteristics of a heavy-bodied petroleum oil and the increased preservative effectiveness of pentachlorophenol in this oil presents a sound technical and economical approach to the treatment of railway crossties. This is particularly true in petroleum-producing regions where the economics would tend to favor the use of a greater percentage of petroleum in the preservative solution. Data show that the pentachlorophenol concentration can be adjusted from the traditional five per cent to a more realistic concentration in line with the past practice and economics dictated in the treatment of crossties, and still maintain a high degree of preservative effectiveness.

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Discussion

P. B. Mayfield (Barrett Div., Allied Chem. & Dye Corp.): In your tests, didn't you find 101-E oil giving as about as good results as creosote

Mr. Olson: The 101-E oil showed no toxicity in soil-block tests. In experimental plots, the oils usually fail quickly but some are better than others.

Eldon A. Behr (Chapman Chemical Co.): In the case of heavy oils such as 101-E, there may be a water relationship. Such an oil apparently holds down the moisture content of the wood.

D. Davies (Koppers Co.): What is the viscosity of 101-E?

Mr. Olson: 104 SUS at 100° F., 30–40 SUS at 210° F.

Lumber Treatment by the Vacuum Process[1]

T. P. WIER, JR.

President, Vacuum Wood Preservers Institute, and Managing Partner, Wood-Protection Co., Houston, Texas

The vacuum process is described with information taken directly from practical commercial experience. Subjects discussed include types of facilities in use, processing range from full cell to empty cell, retentions and penetrations, ease and accuracy of control, limitations of timber size and moisture content, and exposure resistance of treated products. Standard specifications adopted by the vacuum treating industry are presented.

THE BASIC PRINCIPLE of the vacuum process for treating wood involves the removal of air from the cells of the wood by a mechanically produced vacuum, the surrounding of the wood with treating solution while the vacuum is held, and the release of the vacuum to allow the wood to soak and absorb preservative under the influence of atmospheric pressure outside the wood and a vacuum inside the wood. After the desired amount of solution has been absorbed, the preservative is drained from the tank and a "recovery" vacuum is applied to remove the excess preservative from the wood.

Since Garlick's original research (1, 2)[2] on the vacuum process as an improvement over the hot-and-cold-bath method and the kiln-and-cold-bath method, industrial applications of the process have taken four forms:

a) The first form is vacuum treatment with water-repellent preservatives as a replacement for the NWMA 3-minute immersion treatment. These vacuum plants, commonly referred to as the "millwork type", usually are the repetitive, automatic-cycle-type equipment and are commonly located at sources of manufacture. Principal items treated are siding, flooring, sash, doors, frames, and trim. Bradshaw (3) and an anonymous author (4) have reported on this type of use.

b) The second form consists of vacuum treatment with water-repellent preservatives to heavier retentions than in a) to provide maximum preservative protection consistent with paintability. Such a treatment is particularly useful in buildings and for certain difficult-to-treat woods.

c) The third form is vacuum treatment with pentachlorophenol in heavy petroleum solvent to retentions comparable to those commonly used by the pressure treating industry.

d) The last form is vacuum treatment with water-borne solutions such as chromated zinc chloride (5).

Most of the plants that use one or more of the last three procedures custom treat lumber, and are located close to the point of ultimate use. Vacuum treatment with other types of preservatives is also possible but very little has been done in this direction to date, although the potentialities of such a plant for retail lumber yards have been described (6, 7). In addition, Kaufert and others (8) have produced a small low cost vacuum-treating plant that might have an industrial application.

Full Cell or Empty Cell

One point frequently misunderstood is that of whether the vacuum process is a full-cell or an empty-cell treatment. Actually, it can be either, depending on the relative magnitudes of the initial and recovery vacuums. If the initial vacuum is substantially lower than the recovery vacuum, then a large percentage of the absorbed material in the cells can be withdrawn by the recovery vacuum, and the result is an empty-cell treatment.

The data in Table 1 show the amount of material removed from sample cases of different sizes and species. These data were taken from commercial vacuum treating operations. The treating solution contained 5 per cent by weight of pentachlorophenol in a petroleum oil that met AWPA specification P9 for a heavy-petroleum solvent. Recovery of such large amounts of liquid indicates that most of the treatments were of the

Fig. 1.—Load being placed in a partly buried vacuum treating tank. Scale supported on lift arms weighs each load for accurate treating control.

[1] Presented at Session VII, Wood Preservation of the Eleventh National Meeting of the FPRS, held June 23-28, 1957, in Buffalo, New York.

[2] Numbers in parentheses refer to Literature Cited at the end of this paper.

The Author: T. P. Wier holds BS, MA, and PhD degrees in chemical engineering from Rice Institute. Before forming Wood-Protection Co., he was with the research departments of Shell Development Co. and Shell Oil Co. His contributions include processes for electroplating aluminum on steel and producing lubricating oils and work on high-temperature catalytic processes, hydrocarbon analysis, and colloid chemistry. He is owner of Wier Lumber Co. and a founder of the Vacuum Wood Preservers Institute.

empty-cell type. Kaufert's data (8) for air-seasoned fence posts also clearly indicate that he, too, obtained an empty-cell treatment with the vacuum process.

The per cent of recovery obtained in commercial operations varies because of the variation in the gross absorption found necessary to produce the pentration desired for each size and species while at the same time meeting net retention requirements.

It would be appropriate to point out that, in commercial plants, the vacuum readings recorded are not necessarily equilibrium values; that is, the vacuum inside the wood is not necessarily the same as that outside the wood. Therefore, no attempt ordinarily is made to interpret actual vacuum readings, and for this reason they are not included in Table 1. They do serve however, as satisfactory empirical guides for plant operation.

Since a maximum initial vacuum may be required to achieve the desired retention in refractory species, little, if any, of the solution may be removed by the recovery vacuum.

Table 1.—ABSORPTIONS AND RECOVERIES IN VACUUM TREATMENT OF LUMBER

Material treated	Board feet	Gross absorption lb./cu. ft.	Net absorption lb./cu. ft.	Recovery, % of net
Yellow pine (kiln dried and/or air dried)				
2x4 S4S 14′	2,464	9.25	6.06	53
2x4 S4S 10′–8′	1,600	9.38	5.96	57
2x6 S4S 12′–16′)	2,880	9.08	6.04	50
2x10 S4S 12′–16′)				
2x12 S4S 12′)				
2x4 S4S 14′–20′)	3,873	9.77	6.06	61
2x6 S4S 16′)				
2x4 S4S 10′–14′	2,480	10.90	5.89	85
2x4 S4S 20′)	2,309	11.18	6.10	83
2x6 S4S 10′–20′)				
2x8 S4S 14′)				
2x10 S4S 14′–18′)				
2x12 S4S 20′)				
2x4 S4S 8′–10′)	2,280	10.48	6.12	71
2x6 S4S 16′)				
2x8 S4S 10′–16′)				
1x6 S4S 8′–14′	157	21.90	7.00	213
1x4 S4S 8′–16′	1,500	8.70	5.53	57
1x6 CM 10′–20′	648	12.84	6.09	111
4x6 S4S 8′–20′	3,080	9.71	7.39	31
4x8 S4S 12′–18′	187	15.17	7.58	100
6x6 S4S 8′–16′	636	11.04	6.22	78
3x10 S4S 10′	250	16.77	6.65	152
4x4 S4S 12′)	651	18.90	8.70	117
4x8 S4S 14′)				
4x4 S4S 16′)	1,629	4.44	Stock was green; also no recovery vacuum used.	
4x6 S4S 20′)				
4x4 S4S 4′–16′	1,550	10.00	6.04	66
4x4 S4S 8′–18′)	2,270	11.67	6.59	77
4x6 S4S 12′–18′)				
Douglas-fir (air dried and/or green)				
2x4 S4S 10′–18′	1,500	9.18	6.24	46
2x4 S4S 10′–12′)	1,733	9.62	6.21	55
2x6 S4S 12′–16′)				
2x4 S4S 12′–18′	400	8.57	6.73	27
3x4 S4S 12′–14′	1,584	7.55	5.50	37
3x4 S4S 10′–14′	1,608	7.00	5.78	21
White oak (green)				
2x8 Rough 16′	1,195	8.68	6.32	37

Retentions and Penetrations

Garlick's early work (1, 2) clearly showed that, by varying the initial vacuum and the soak time, retentions could be produced that ranged from one pound per cubic foot to over 16 pounds per cubic foot for dry southern yellow pine and from one pound per cubic foot to 9.6 pounds per cubic foot for incised Douglas-fir. Commercial treatments have produced retentions higher than these. This range readily covers most commercial practice for the light construction industry, however. There are some areas of the heavy construction field where higher retentions would be required or where the timber sizes would be greater than can be treated satisfactorily by the vacuum process without the benefit of a pressure boost.

When wood is treated with pentachlorophenol in heavy petroleum oils such as those that meet AWPA specification P9 for heavy petroleum solvent, to retentions of 6 pounds per cubic foot of 5 per cent solution or over, (or for that matter with creosote or aqueous chromated zinc chloride solutions) penetration becomes a part of specifications.

For 1-inch, 2-inch, 3-inch, and 4-inch thicknesses of dry lumber of the most commonly treated species, commercial vacuum plants can readily meet the penetration and retention requirements of Federal Specifications TT–W–571c. Compliance with federal specifications has been attested to in reports of commercial inspection laboratories.

Blew (9) has attempted to compare pressure and vacuum processes for treating both seasoned and unseasoned southern pine and Douglas-fir. This study has been widely misinterpreted as indicating that commercial pressure treatment is superior to commercial vacuum treatment. Actually, the study was not made on products as commercially produced by either pressure or vacuum treatment. Both processes can meet standard specifications. When properly interpreted, the report serves as a useful first step in a study of the limitations of treating by pressure, vacuum, steaming and vacuum, steaming and soaking, cold soaking, and three-minute dipping. As far as the vacuum process is concerned, the study confirmed certain limitations recognized by vacuum treaters.

Where retentions of 6 pounds per cubic foot or more are required with unseasoned pine, the vacuum process usually is too slow to be practical, and in many cases will not produce the desired retention.

Timbers larger than 4 inches in thickness usually fall outside the range of commercial vacuum treating practice for two reasons. In the first place, such timbers are usually green and most vacuum plants do not include steaming facilities for seasoning. In the second place, the distance to be penetrated makes the soaking time required too long without the benefit of a pressure boost. Satisfactory results have been obtained with somewhat larger timbers when they were properly air-seasoned (note data on 6x6's in Table 1).

To obtain the maximum penetration for the retention involved, it is important to use the lowest possible initial vacuum that can produce the desired gross absorption in a reasonable time. For example, an initial vacuum of 18 inches applied to kiln-dried 2 by 6 yellow pine and held for 15 minutes before admitting the solution slowly without change in vacuum produced 100 per cent sapwood penetration in every piece bored. The gross absorption was 11 pounds per cubic foot, and the net was 7 pounds per cubic foot.

On the other hand, on a charge made up from pieces from the same shipment, a quick 28-inch initial vacuum applied as the solution was drawn into the treating tank produced only ½ to 1-inch penetration, even though the gross absorption was 10 pounds per cubic foot and the net was 6 pounds per cubic foot. In this case, the concentration of preservative was visibly quite high in the portion that was penetrated.

It has also been observed in treating kiln-dried 4 by 5 inch double tongue and groove Canadian cedar heartwood, which was extremely difficult to penetrate, that a higher absorption was obtained by applying the maximum 29-inch vacuum to the wood in an empty tank for 45 minutes before introducing the preservative than was obtained by merely bringing the vacuum up to 29 inches before the solution was introduced. In both cases, the

solution was admitted slowly to maintain the maximum vacuum during filling of the tank (5 to 10 minutes). It appears that vacuum equilibrium had not been reached. Both of the above procedures produced more absorption than was obtained by filling the tank as the vacuum was applied, even though the final vacuum reading was the same.

It is known that separation of charges according to species and thickness of individual pieces will yield more uniform results in any process. The size of charges in vacuum plants makes this separation quite practical.

With water-repellent preservatives, treatments are usually confined to retentions of approximately 2 pounds per cubic foot to provide a preservative-treated product that can be offered to the trade with: a) excellent painting characteristics, b) lack of bleeding into absorbent materials such as oak flooring, gypsum board, acoustical material and plaster, c) improved dimensional stability, and d) reduced grain raising and checking. The ability of the construction trade to rely on paintability and non-bleeding properties is quite important, since correction of such a difficulty on a job may prove to be several times more expensive than the cost of treating. Garlick (10, 11, 12, 13), Verrall (15, 16) and Browne (17) have amply demonstrated that water-repellent properties are highly valuable both for decay protection and to make wood a better product.

Process Control

As originally designed and currently used, most custom vacuum treating plants treat to the desired retention by 1) estimating both the vacuum and time factors of a cycle for proper absorption, then checking the actual absorption by weighing, and 2) estimating both the vacuum and time factors for proper recovery of excess solution. The cycle is arbitrarily carried out, and the accuracy depends to a large extent on the ability and experience of the plant operator.

Much better control can be obtained by simple arrangements that permit the measurement of treating progress during the operation. The equipment requirements are a smooth, sloping bottom on the treating tank, a sight glass in the upper level of the tank for an absorption gage, and a sight glass in the lowest level of the tank-drain system to serve as a recovery gage. The upper portion of the tank and the lower section of the drain are empirically calibrated directly in pounds or gallons to measure absorption and recovery, respectively.

The need for weighing before and after absorption and recovery is not eliminated, but with this arrangement it is only necessary to estimate the initial vacuum closely enough so that the absorption cycle will be a reasonable time. The actual absorption time is determined by watching the sight gage to determine when a suitable excess of solution has been absorbed. No estimating need be done during the recovery cycle, if the vacuum pump is started and recovery sight gage is watched until the proper final retention has been reached. The net retention of an individual charge can ordinarily be controlled to within 2 or 3 per cent.

Exposure Resistance of Products

When wood is treated to a retention of 6 pounds per cubic foot with a 5 per cent by weight solution of a pentachlorophenol-petroleum oil in which the petroleum oil meets AWPA specification P9 for heavy petroleum solvent, a high degree of exposure resistance for above-ground use results. For use in the ground, it is common practice to specify 8 to 10 pounds per cubic foot retentions.

The foregoing discussion has pointed out that the vacuum process can be used with oils that meet the heavy oil specification to produce these retentions, while at the same time producing penetrations that meet accepted standards such as Federal Specifications TT–W–571c for the more commonly treated species (provided that the material is seasoned properly and that the size of the material to be treated is within the range of that normally used for the light construction industry). Blew's data (9) indicated that similar results could be obtained with creosote oils, but lumber commercially treated in this way is not being offered to the trade at the present time.

Verrall (15, 16) has reported a considerable extention in life for wood in above-ground structures as a result of simple dip or soak treatments with water-repellent preservatives. Where material is vacuum treated with solutions containing pentachlorophenol and satisfactory water-repellent materials to a net retention of 2 pounds per cubic foot or higher, even better results may reasonably be expected.

For example, the exposure resistance of the operator walkway at the battery of slurry centrifuges at the Imperial Sugar Co., Sugar Land, Texas, plant may be cited. In April, 1953, the wood in the platform was replaced with kiln-dried southern yellow pine that was vacuum treated with pentachlorophenol-water repellent preservative solution to a net retention of 24 gallons per MBM. The walkway is washed down every eight hours, seven days a week, year after year. Prior to the use of the treated lumber, it was necessary to replace the platform every three years. Recent inspection of this lumber shows practically no surface checks or raised grain after this severe exposure. The bolts with which the platform is assembled are clean and free from rust, and the bolt holes in the wood are tight and sound. The treated wood had been in use over three and a half years at the time the picture in Fig. 3 was taken, and the picture will attest to the fact that many more years of usage can be expected. The cleanliness and relative freedom from odor of the pentachlorophenol-water repellent treated wood are additional advantages.

Another case involves the bleacher seats of the Southern Methodist University baseball stadium. These seats were installed early in 1950. A total of 12,435 board feet of kiln-dried southern yellow pine, vacuum-treated with pentachlorophenol-water repellent preservative, was used in the construction. In 1957 the first replacement of material occurred, when 133 board feet, or approximately 1 per cent re-

Fig. 2.—The work tanks and part of the vacuum tank are underground. This construction-stage photograph shows part of what goes unseen at a vacuum treating plant. The buried portion of the vacuum work (far right) is black. The mast is support for the hydraulic cover-raising mechanism.

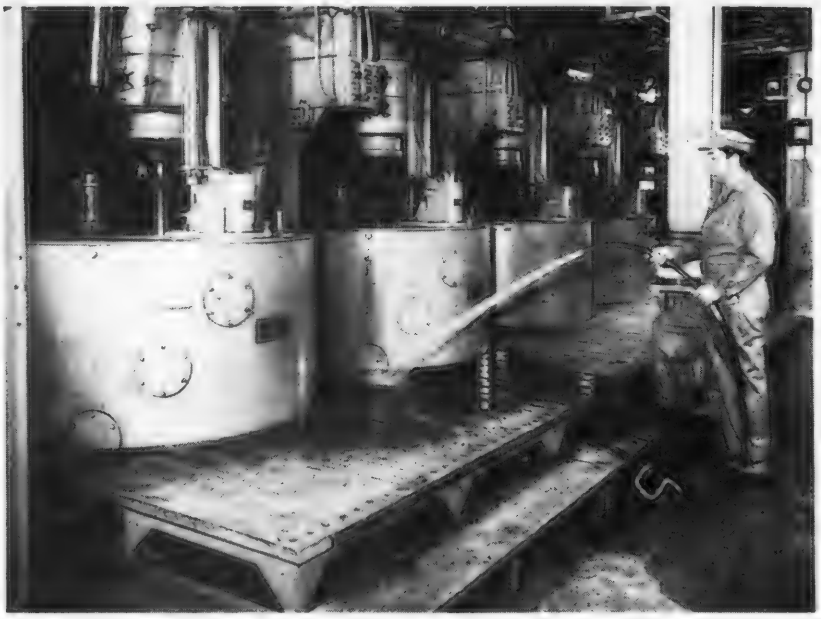

Fig. 3.—Condition of water-repellent vacuum-treated lumber after over 3 years of service.

placement, was required to have the stadium in excellent shape. Inspection indicated that the treatment also had successfully combated the tendency of southern yellow pine to warp and twist and had minimized grain raising, a very important aspect in stadium seating. The treatment was to a net retention of 23.4 gallons per MBM, and was carried out by Cowser and Company, Dallas, Texas.

In buildings with plaster construction, use of plaster grounds and door and window bucks vacuum treated with water-repellent preservative is ideal for providing high exposure resistance combined with non-bleeding properties. This is pointed up by such cases as that of a research laboratory built in Houston by a major oil company several years ago. The construction was started with plaster grounds pressure treated with a water-borne salt solution in accordance with federal specifications. Although the material was kiln dried after treatment, when the plastering began, bleeding of the water-borne salt so discolored the plaster that a switch to wood vacuum treated with water-repellent preservative was made. The entirely satisfactory results that followed are typical of many other cases. This emphasizes the point that treatments should be selected according to the use to be made of the treated product. Just as a treatment of 2 pounds per cubic foot with water-repellent preservative is not suited to in-soil use, treatments designed for use in the ground are not always suited for use in buildings. The Vacuum Wood Preservers Institute collects such case histories and publishes them at intervals. These case histories are available from the VWPI.

Standard Specifications

The Vacuum Wood Preservers Institute has adopted a standard specification for the industry entitled "Treatment of Wood for Use in Buildings". The specification is published verbatim to serve as a permanent record to which reference may be made by those involved in further research and development of the subject. This specification was the result of several years of study by the Institute, and was based on over 10 years of experience with the process and over 20 years of experience with the preservatives involved. The Specification appears on the following page.

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Discussion

Richard V. Vaughn (L. Vaughn Co.): Can you use the vacuum process with salts for fireproofing?

Dr. Wier: I can't answer that except to say that chromated zinc chloride is used in the treating plant of Poupore Lumber Co. in Canada.

Mr. Vaughn: Does such a treatment, that is, with salts, meet AWPI specifications?

Thomas H. Lloyd (Poupore Lumber Co.): It meets specifications for salt-treated lumber, but not for fireproofed lumber.

Mr. Vaughn: Do you kiln-dry after treatment?

Mr. Lloyd: If you want dry lumber, yes. If you do not particularly want a low moisture content, no.

B. C. Williams (Norfolk Naval Shipyard): Have you made any regularly scheduled checks of the concentration of pentachlorophenol in the recovered oil?

Dr. Wier: No, not regularly scheduled. Occasional checks in the past indicated no change. There is no heat used by vacuum plants, which eliminates the changes due to vaporization.

W. C. Hopkins (Louisiana State University): Results of research with the cold-soaking process conducted by members of the Coordinated Wood Preservation Council showed slight reductions in penta concentration in almost every instance. In other words, the wood used seemed to have greater affinity for the penta than for the carrier (Usually No. 2 fuel oil).

Mr. Williams: Have you encountered any sludging or anything of the sort in the use of water-repellent preservatives?

Dr. Wier: There has been some sludging on rare occasions. This was several years ago, and we have had no difficulty in the last several years.

VACUUM WOOD PRESERVERS INSTITUTE

June, 1956

Treatment of Wood For Use in Buildings

Scope:

This specification covers treatment of wood for use in buildings with an oil-borne preservative to protect it against decay staining fungi, termites and other wood-destroying insects; or with a water-repellent preservative to protect it against the aforementioned and in addition against swelling, shrinking, checking, warping and paint blistering.

Preservatives:

1. Water-repellent preservative. — The preservative must meet the requirements of the National Woodwork Manufacturers Association or Federal Specification TTW–572. (Such a material contains a minimum of 5% by weight of pentachlorophenol or a blend of chlorinated phenols, either one combined with water repellents and a clean solvent).

2. Oil-Borne preservative.—The preservative must contain a minimum of 5% by weight of pentachlorophenol meeting Federal Specifications TTW–570 dissolved in an oil meeting APWA Specification P–9 for heavy petroleum solvent.

Methods of Treatment:

1. Soak Method.—Immerse the wood in the solution at room temperature for a period to produce the retention desired. As an optional step after soaking, a vacuum may be applied to recover any excess preservative.

2. Vacuum Method.—Vacuum treatment involves the following cycle: a) An initial vacuum to remove air from the cells of the wood with either simultaneous or subsequent filling of the chamber with the preservative with the vacuum on; b) Release of the vacuum and soaking to force the preservative into the submerged wood under atmospheric pressure to an amount in excess of the net retention required; and c) Draining of the chamber and application of the final (recovery) vacuum in an empty chamber to remove excess preservative until the required net retention is obtained.

Treating Requirements:

For the applicable specifications which shall be used in the treatment of wood for use in buildings, see Table I—Schedule of Wood Treatment.

Whenever the quantity of material ordered is sufficient, lumber and timbers of different thicknesses and retention requirements shall be treated in separate charges. When this is impractical, they may be treated in the same charge, provided that the total net retention for the charge shall be not less than the sum of the required retentions for the quantities of each size group in the charge, and provided that desired properties such as paintability or minimum retention are not materially changed thereby.

Job Site Handling:

All sawcuts, borings, etc. shall be liberally brushed with or dipped in the same preservative used in treating. Before applying paint, plaster or other absorbent material, the contractor should ascertain that the treatment has thoroughly dried. For maximum benefit where moisture control is critical, treated material should be protected from the elements with the same precautions as for untreated material.

Table 1.—SPECIFICATION V-1. SCHEDULE OF WOOD TREATMENT

Desired Properties[1]	Items in Commercial Buildings[2]	Items in Residential Buildings[2]	Preservatives	Retention[3],[4]	Penetration[5]
High preservative value where bleeding is not a detriment	Screeds or sleepers where under subfloor; sills; floor joists; bridging; bottom plates	Bottom plates on slab foundation; all wood below subfloor for crawl space and basement type construction.	Oil-borne preservative	6 lb./cu. ft. Vacuum or pressure method	The penetration in the sapwood shall be not less than 2½ inches unless 85% of the sapwood depth is penetrated. Maximum penetration for retention involved
			Water-repellent preservative	2 lb./cu. ft. Vacuum or pressure method	
High preservative value where non-bleeding, paintability[6] or reduced swelling and shrinking are desired	Screeds or sleepers where used as subfloor; other subflooring; door and window bucks; plaster grounds; furring strips; all exterior lumber; roof cant strips; all wood encased in decorative metal; decking and sheathing exposed to more severe condensing conditions	Screeds on slab construction; subfloor and bottom plates for crawl space and basement type construction; exterior wood to be stained	Water-repellent preservative	2 lb./cu. ft. Vacuum or pressure method	Maximum penetration for retention involved
Resistance to moderate exposure where non-bleeding, paintability[7] or reduced swelling and shrinking are desired	All framing lumber above bottom plate; finish flooring; redwood; millwork; other decking and sheathing; roof nailing strips; wood panelling; and wood not mentioned elsewhere	Exterior wood to be painted or varnished; finish flooring; other items as desired[2]	Water-repellent preservative	1 lb./cu. ft. Vacuum or soak method	

Footnotes:

[1]For best results dry lumber should be used. Where swelling and shrinking control is the prime consideration the wood should be dried before treating to a moisture content as nearly as possible equal to that involved in the conditions of its use.

[2]If for an item in a particular building, properties other than those indicated for it in the schedule are desired, the proper treatment to use to achieve the desired properties may be ascertained by consulting Column 1.

[3]Retentions are to be measured by weighing.

[4]Where it is impractical to obtain retentions specified, treatment shall be to refusal.

[5]Recommended equipment for penetration testing includes: increment borer, chemicals for testing for heartwood content, chemical testing for presence of pentachlorophenol and powdered dye for testing oil penetration.

[6]Paintable without bleeding approximately 14 days after treatment.

[7]Paintable without bleeding approximately 24 to 48 hours after treatment.

Special Items:

Plywood—Soak treat with water-repellent preservative for 30 seconds.
Shingles (roof, 4 bdl./sq.) Soak treat with water-repellent preservative to retain 2 gal./sq.
Shakes (machine, sidewall 2 bdl./sq.) Soak treat with water-repellent preservative to retain 1 gal. sq.
Doors (hollow core, slab) Brush coat with water-repellent preservative.

Application of the Logistic Function to Toxicity Testing of Wood Preservatives[1]

T. S. McKNIGHT

Ottawa Laboratory, Forest Products Laboratories of Canada, Department of Northern Affairs and National Resources, Ottawa, Ontario

The logistic function was found to be more descriptive of the action of a fungicide over the whole range of concentrations than was the threshold value, which only defines one point. The advantage of this function becomes especially apparent in the case of weakly toxic substances, which can be adequately described by this method although the threshold value cannot be found.

THE ABILITY OF A FUNGICIDE to inhibit the decay of wood is measured by means of a soil-block test (1, 2)[1]. In this test, a series of blocks of wood is treated with a graded concentration of fungicide, and is then subjected to decay under closely controlled conditions. If the range of fungicide concentrations has been properly chosen, it is found that the blocks with the lightest treatment are decayed, as measured by the weight loss of the sample, and that the decay decreases as the fungicide content of the blocks increases. The blocks with the heaviest treatments are found to be almost undecayed when an effective fungicide is used.

Experimental values obtained in a typical set of soil-block tests of pentachlorophenol-treated wood are plotted in Fig. 1. This test was of pentachlorophenol deposited from toluene in red pine sapwood, and the wood-destroying fungus used was *L. trabea*. It can be seen that decay is markedly reduced in the neighborhood of 0.04 pound of pentachlorophenol per cubic foot of wood, and that two straight lines drawn through the data as shown will intersect near this value.

This useful point, called the threshold value (2, 3) is used to evaluate the toxicity of a fungicide. The threshold value does not, however, give a complete description of the action of the fungicide since it does not include information about the rate of change of the effectiveness of the fungicide with concentration. It has also been found that the toxicity of certain poor fungicides such as weakly toxic oils cannot be described by this point since there is no marked reduction in decay at any one point, as can be seen from the data of Duncan and Richards (2) plotted in Fig. 3. Obviously, it would be advantageous to evaluate both strong preservatives and the weakly toxic oils used as carriers by the same method. An attempt to do this is described in this paper.

Development of Logistic Data

The majority of the data that are used to illustrate the method of calculation (and data treatment) were obtained in a recent investigation carried out at the Ottawa Laboratory, Forest Products Laboratories of Canada. The data were obtained from decay tests, of the buried-block type, with pentachlorophenol as deposited in wood from a variety of volatile solvents. Reference has also been made to other data obtained from the literature.

Graphs of the results of the buried-block tests with the very toxic fungicide, pentachlorophenol, were found to exhibit the sigmoid form common to many types of toxicity tests; that is, the effect of an increase in the dose of fungicide is small for small doses, then becomes larger as the dose is increased, and finally it becomes small again for large doses. Both the integrated normal curve and the similar logistic function have been used to represent these results. The basis for the use of these curves has been discussed by Bliss (4) and Berkson (5); a general discussion of these curves, called biological response curves, has been given by Westerfeld (6).

The integrated normal curve was used by Bliss (4), who converted the percentage effect of a dose into a quantity called the "probit", which was then plotted with the dose, or some function of the dose such as the logarithm, to obtain a straight line. The "probit", obtained from tables, is the normal equivalent deviation to which five has been added to avoid negative values. The constants of the straight line are then obtained by calculation as outlined by Bliss. The accuracy of a graphical solution of this curve has been discussed by Litchfield and Fertig (7).

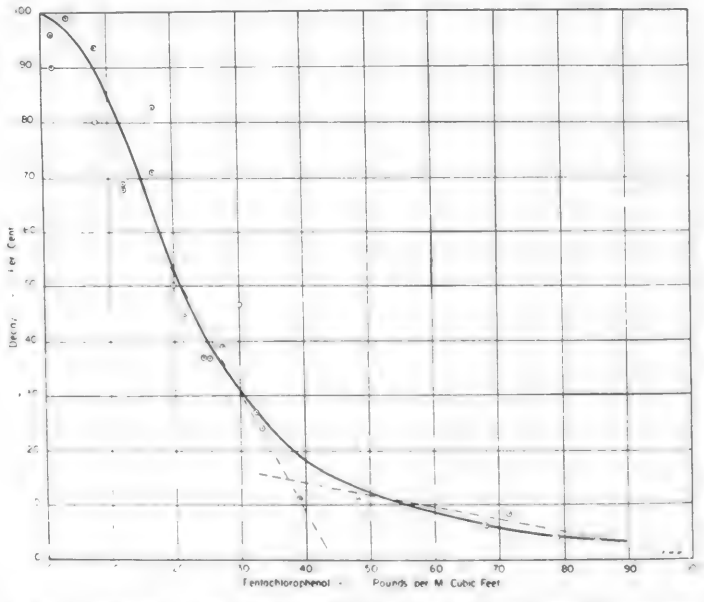

Fig. 1.—Decay of red pine sapwood blocks, treated with pentachlorophenol in toluene, on exposure to *L. trabea*.

[1] Numbers in parentheses refer to the Literature Cited at the end of this paper.

The Author: T. S. McKnight holds an MA degree from Queen's University, Kingston, Ontario. He is presently with the Wood Chemistry and Preservation Section of the Ottawa Laboratory.

Berkson has found that the logistic function is equally satisfactory for the representation of the data and that it is simpler to apply (5). This function, then, has been applied to the test results considered here.

The logistic function,

$$Q = \frac{1}{1 + e^{-(\alpha+\beta x)}} \qquad (1)$$

can be written in the form of a straight line,

$$\ln \frac{Q}{1-Q} = \alpha + \beta x \qquad (2)$$

for ease in plotting and fitting. Q is the response rate or the fraction of individuals in a group which respond in some way at a given dose. Berkson has named the quantity $\ln \frac{Q}{1-Q}$ the "logit" of Q by analogy with the "probit" of Bliss. The independent variable x is the logarithm of the dose. This logarithmic transformation has been found to give a better fit for many data, and its use is discussed by Gaddum (8).

The form in which the equation is used here is,

$$l + 5 = a + b \log x \qquad (2a)$$

in which l is the logit and x is the dose. Five is added to the logit and not incorporated in the constant a to avoid negative values. The constants a and b were found by the method of least squares.

Table 1.—SAMPLE CALCULATION—PENTACHLOROPHENOL DEPOSITED IN RED PINE SAPWOOD FROM TOLUENE. ORGANISM *L. TRABEA*

"Penta" dose lb./cu. ft. x 10^3 x	Weight loss or response rate (as % of control) q	Log (dose x 10^3) log x	Logit+5 l+5
1.65	95.6	0.218	1.933
1.47	89.5	0.167	2.858
4.14	99.3	0.617	0.045
8.54	94.1	0.932	2.232
8.62	79.7	0.936	3.633
12.5	67.5	1.097	4.269
12.6	69.0	1.100	4.200
16.9	71.2	1.228	4.095
17.1	83.3	1.233	3.394
20.1	50.3	1.303	4.990
21.4	44.8	1.330	5.208
25.3	37.1	1.403	5.528
24.6	36.7	1.391	5.545
30.2	47.4	1.480	5.210
27.4	38.9	1.438	5.452
33.3	23.7	1.522	6.170
32.0	27.0	1.505	5.995
48.1	10.7	1.682	7.121
39.1	11.3	1.592	7.060
71.2	7.6	1.853	7.497
68.1	6.1	1.833	7.742
84.5	3.6	1.927	8.295
79.0	4.2	1.898	8.135

$\Sigma \log x = 28.683 \quad \overline{\log x} = 1.4342$

$\Sigma(l+5) = 111.77 \quad \overline{l+5} = 5.5886$

$\Sigma(\log x)^2 = 42.869 \quad \Sigma(l+5)^2 = 678.220$

$\Sigma(l+5) \log x = 169.584$

$b = 5.363$

$a = 5.5886 - 5.363 \times 1.4342 = 2.1030$

$\therefore l+5 = 5.363 \log x - 2.103$

$r = 0.96.$

For the purpose of calculation, the dose x 10^3 was used. If this is corrected to the true dose, then

$l+5 = 5.363 \log x + 13.986$

Table 2.—VALUES CALCULATED FROM CONSTANTS GIVEN IN TABLE 1 FOR TOLUENE SERIES

l+5	q	log x	Dose (x 10^3)
0	99.3	0.3921	2.47 lb./cu. ft.
1	98.2	0.5785	3.79
2	95.3	0.7651	5.82
3	88.1	0.9515	8.95
4	73.1	1.1380	13.7
5	50.0	1.3244	21.1
6	26.9	1.5109	32.4
6.5	18.3	1.6041	40.2
7	11.9	1.6973	49.8
7.5	7.6	1.7906	61.8
8	4.7	1.8838	76.6
9	1.8	2.0703	118
10	0.7	2.2567	181

Table 3.—SUMMARY OF EQUATION CONSTANTS FOR VARIOUS SOIL-BLOCK SERIES

Solvent *L. trabea* series	a	b	r
Benzene	14.951	6.462	0.96
Toluene	13.986	5.363	0.96
n-Butanol	14.832	6.151	0.95
n-Propanol	15.021	6.530	0.93
Ethanol	14.952	6.147	0.95
"Cellosolve"	16.055	6.911	0.94
Benzene+5% cellosolve	15.327	6.472	0.95
Weakly toxic oils*			
Denver No. 3 blend*	2.437	2.710	0.98
No. 400 Fuel Oil*	1.476	4.217	0.99
5% "penta" in heavy gas oil†	2.314	9.513	0.98

*Data of Duncan and Richards (2).
†Data of Duncan (8).

The regression coefficient, r, which indicates the goodness of fit, was also calculated.

$$r = \frac{n\Sigma(l+5)\log x - \Sigma \log x \, \Sigma(l+5)}{\sqrt{[n\Sigma(\log x)^2 - (\Sigma \log x)^2][n\Sigma(l+5)^2 - \Sigma(l+5)^2]}} \qquad (4)$$

$$b = \frac{\Sigma(l+5)\log x - n\overline{(l+5)}\,\overline{(\log x)}}{\Sigma(\log x)^2 - n\overline{(\log x)}^2}$$

$$a = \overline{(l+5)} - b\,\overline{\log x} \qquad (3)$$

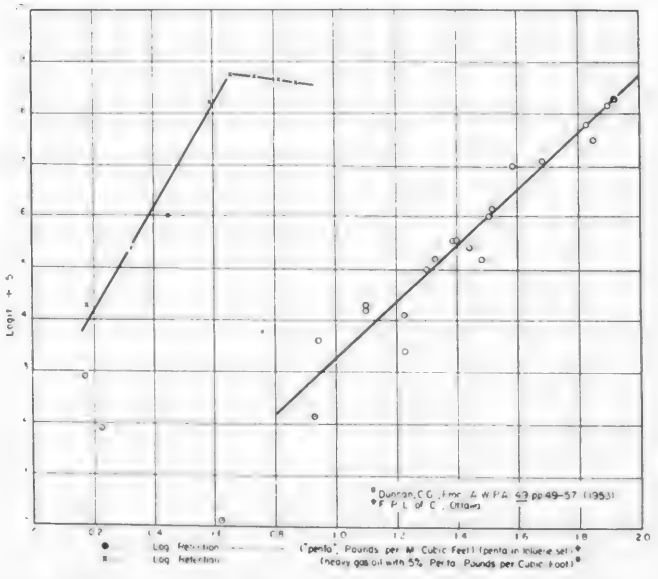
Logit + 5
Log Regression
Log Retention
("Penta" Pounds per M Cubic Feet (penta in toluene solv.)
(heavy gas oil with 5% Penta Pounds per Cubic Foot)
Duncan, C.G., Jour. A.W.P.A. 43 pp 49-57 (1953)
F.P.L. (Oil.)

Fig. 2.—Data plotted in the straight line form of the logistic function.

Results

The logistic curve constants for various sets of decay data were calculated as shown in Table 1. The logit was found from the experimental response rate, q, which was modified to fit the present case by taking it to be the weight loss by decay of the test block expressed as a per cent of the mean weight loss of the controls. The logit versus the log of the dose is plotted in Fig. 2 together with the calculated least squares line. The least squares line was calculated only for data above 6.3 x 10^{-3} pound per cubic foot, since the q values at the lowest dose levels were found to be excessively scattered. This region of high decay, however, is not of interest in wood preservation and little was lost by its omission. The data deleted from the calculation shown in Table 1 are only those above the dotted line.

Theoretical values of doses at various decay levels were calculated from the curve constants of the data of Table 1; these are listed in Table 2. The curve drawn through the data in Fig. 1 was constructed from these points.

The curve constants of this set of data and a number of other sets obtained in this Laboratory are listed in Table 3. All these data were obtained from similar sets of soil-block tests that differed from each other only in the solvent from which the pentachlorophenol was deposited.

The regression coefficients of the least squares lines are also listed, and it may be seen that they are close to one, which was taken as an indication of goodness of fit to the experimental points. The calculations are not particularly lengthy, but it is possible that they might be further shortened by classifying the results into retention levels and taking the mean decay for each level. This method would also increase the closeness of fit of the data to the calculated curve.

The results of the decay test can be described by the two constants listed in Table 3. It is also possible to report values for any arbitrarily chosen level of decay, since, in some cases, the threshold value cannot be found. This is a definite advantage of the proposed method of evaluation. In pharmacology, the dose of biologically active substance required to give a response of fifty per cent is often specified. This point is the mid-point of the curve, for which the logit is zero, and its logarithm is seen from equation (2a) to have the value $(5 - a)/b$. However, decay levels below the fifty per cent level might be of more interest in wood preservation, and these could be taken at any arbitrary decay level, such as at 27 or 12 per cent where the logit is one and two, respectively.

The fungicidal properties of some substances cannot be described by the threshold value. To illustrate this, the results of wood decay tests of two weakly toxic oils (2) are plotted in Fig. 3. It may be seen that decay is not depressed rapidly and completely enough to give the sharp "knee" in the curve from which a threshold value could be taken. The logistic function, however, as calculated from the data, was found to give a reasonable fit as can be seen from the values of the regression coefficients for the least squares line (Table 3). The regression coefficients and curve constants are given in this table, and the calculated logistic curves are plotted as the heavy lines through the data in Fig. 3. The evaluation of the properties of weakly toxic oils can be made by the logistic function method, then, and may prove useful in the investigation of their properties.

The results of the decay test can depart from the logistic function when factors other than decay are operating,

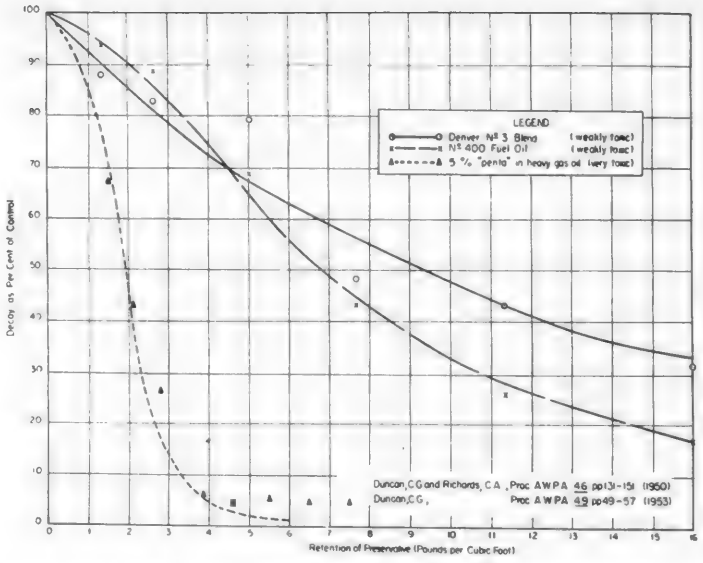
LEGEND
Denver № 3 Blend (weakly toxic)
№ 400 Fuel Oil (weakly toxic)
5 % "penta" in heavy gas oil (very toxic)
Decay as Per Cent of Control
Retention of Preservative (Pounds per Cubic Foot)
Duncan, C.G. and Richards, C.A., Proc. A.W.P.A. 46 pp131-151 (1950)
Duncan, C.G., Proc. A.W.P.A. 49 pp49-57 (1953)

Fig. 3.—Soil block tests—results obtained by Duncan and Richards with weakly toxic oils, and by Duncan with a highly toxic preservative.

as, for instance, when the weight loss of the wood samples is due to the loss of preservative. This loss may be caused by leaching, weathering, or migrating into the soil of the test jars. These losses, which have been termed "operational", are shown clearly in Fig. 3 where the results of a decay test with 5 per cent pentachlorophenol in heavy gas oil are plotted (9). The points in the region of heaviest retention are seen to follow an almost horizontal straight line and not to approach values of zero decay as indicated by the broken line. The broken line in Fig. 3 shows the path of logistic function fitted to the data representing weight loss by decay. The logistic function constants are shown in Table 3. The operational weight losses of the blocks can be distinguished easily from the weight loss values due to decay by plotting the data as the logit against the log retention. In Fig. 2 this has been done, and it is seen that there is a break in the line where operational weight losses begin.

The threshold value of the preservative used in this test was taken to be the point at which the operational weight loss line intersected the decay weight loss line (9, 10). This value, however, is not definite but is conditional on the position of the operational weight loss line, which, in turn, depends on the handling of the blocks. It might be better, then, to describe the properties of the preservative by means of the logistic function constants and report operational losses separately.

Conclusions

Although the great advantage of the threshold value is that it is the most convenient single point on which to compare preservatives, it appears that the logistic function can be used to describe the wood-preserving value of fungicides of both strong and weak toxicity. This method, then, is of wider applicability than is the threshold value, which can only be found for strong fungicides. It also appears that operational losses, which can be easily detected on the logit—log dose plot, leave the logistic constants unchanged although they can alter the apparent position of the threshold value.

Another practical advantage of the logistic method of expressing the results of decay tests is that it gives information concerning the rate of change in effectiveness of a fungicide before the threshold value is reached; one fungicide might permit very slow decay but another might permit rapid decay in the region below the threshold.

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End Gluing Lumber[1]

D. B. RICHARDS

Forestry Department, Agricultural Experiment Station, Alabama Polytechnic Institute, Auburn

Various types of end-joints are discussed both with respect to their strength and ease of production. Production equipment is evaluated and recommendations are made for improvements and new designs.

A DECADE AGO, the laminating industry plus a few millwork factories accounted for most of the end-jointing done in this country. Today there are many lumber companies as well as remanufacturing plants among the scores of companies that are end-jointing. The rising cost of raw material plus its smaller average size will continue to stimulate an interest in end-jointing in the woodworking industry.

Three technical problems of end-jointing are of special importance today. They are (1) design of higher strength, production-type joints, (2) development of better glues, and (3) design of more efficient machinery, particularly for pressing and curing the joints.

TENSILE STRENGTH OF END-JOINTS

Plain Scarf Joints

For high-strength uses, such as marine lamination and splicing aircraft spars, the plain scarf joint is unexcelled. Work at Auburn has indicated that plain scarf joints with a slope of 1:9 or flatter will yield average tensile strengths of about 15,000 psi in uniform growth southern pine and about 20,000 psi in white ash. These values represent from 70 to 76 per cent of the control values. While these per cent strength values may not seem too impressive, it should be noted that the absolute values for joint strength in pounds per square inch are higher than even the clear wood control values of some comparable studies whose deceptively high strength ratios are based not so much on strong joints as on weak control values. In view of this somewhat confusing situation, it would seem wise in the future to put more emphasis on the absolute strength of the end-joints, particularly when suspiciously low control values are reported.

Only small additional strength is obtained by flattening the slope beyond 1:9. For example, a 1:15 slope yields strength ratios between 80 and 86 per cent.

Despite its advantages of simplicity and high strength, the plain scarf joint is wasteful of wood and is difficult to fabricate, assemble, and cure under high-speed production conditions. For these reasons, it is believed that the plain scarf joint will not prove a satisfactory joint for lumber production, although it probably will continue to be used in the laminating industry.

Finger Joints

Because it is well adapted to high-speed production, the finger joint is the end joint most commonly used in the lumber industry today. Unfortunately, the commonly used joints of this type (Fig. 1) are rather weak, yielding from 2,000 to 5,000 psi in Douglas-fir or southern pine when tested in tension parallel to the grain. With reasonably strong controls, such values usually give strength ratios of 15 to 25 per cent of the controls. With unusually weak controls, strength ratios as high as 46 per cent have been reported for this type of joint.[2] However, such high values are probably unrealistic, since the absolute strength is generally less than 5,000 psi.

Most finger joints are between 5/8 and 1¼ inches long, have rather flat scarfs (in the neighborhood of 1:12 slope) on the sides of the fingers, and have relatively thick tips (from 3/32 to 3/16 inch thick, Fig. 1). The obvious weakness of this type of joint is in the thick tips, which not only carry no load themselves but, by transferring their load to the nearby wood, cause a

[2] Luxford, R. F., and R. H. Krone. 1946. End-joints of various types in Douglas-fir and white oak compared for strength. U. S. Forest Products Lab. Report R1622.

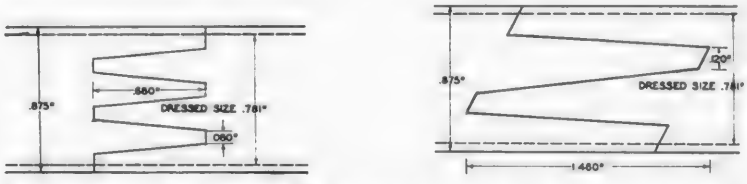

Fig. 1.—Typical finger joints of the type in common use today as seen in edge view. The obvious weakness of these joints is the relatively thick tips on the fingers plus the location of truncated tips at the most damaging position, the surface of the board. Such joints usually yield tensile strength values between 2,000 and 5,000 psi in southern pine.

Fig. 2.—This end-glued 1 by 4 is supporting in excess of 530 pounds over a four-foot span. The board was surfaced after it was glued, so the actual thickness is only 25/32 inch. Note that there is a finger joint between the feet of each man.

[1] Presented at Session I, Glues and Gluing, of the FPRS' Eleventh National Meeting, June 23-25, in Buffalo, N. Y.

The Author: D. B. Richards attended Park College, Mo., and received a BS degree in forestry from Colorado A & M. He also holds MS and PhD degrees from the New York State College of Forestry, Syracuse. He was an instructor in wood utilization at Syracuse, and a wood technologist and lacquer chemist before joining the Auburn faculty in 1951.

damaging stress concentration in the wood. These joints typically break in the wood beside the joint tip and give rise to the erroneous statement that the joint is "stronger than the wood itself" despite the fact that the joint usually breaks at a strength less than ¼ that of "the wood itself."

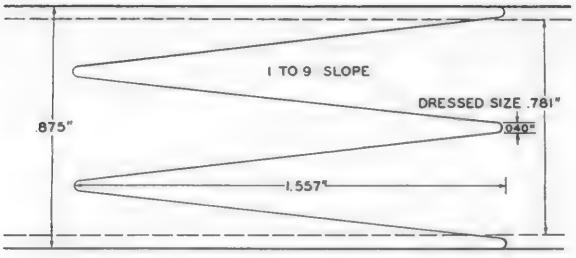

Fig. 3.—The Auburn B-joint as seen in edge view.

Fingered Scarf Joints

In an effort to combine strength of the plain scarf joint with high-speed production advantage of the finger joint, the fingered scarf joint was developed.[3] This joint is similar to the finger joint except that an effort is made to reduce the damaging stress concentrations by employing fewer fingers with thinner tips. For a given thickness of lumber, such a design requires that the fingers be longer than those of a standard finger joint, or else the slope of the scarf be steeper. Actually, a combination of these two possible design changes may prove successful, since in softwoods, at least, slopes as steep as 1:8 are strong enough that stress concentrations at the finger tips still seem to be the limiting factor on joint strength.

The Auburn B-joint, the Auburn E-joint, and the Auburn-Warner joint, are offered as examples of the fingered scarf joint (Figs. 2, 3, and 4). The Auburn B-joint has fingers 1.557 inches long with a 1:9 slope of scarf and 0.040 inch tips. The Auburn E-joint has fingers 0.984 inch long with a 1:8 slope of scarf and 0.016 inch tips. The Auburn-Warner joint has fingers 0.806 inch long with a 1:10 slope of scarf and 0.040 inch tips. The Auburn B- and E-joints have proved very similar in strength, yielding average tensile strengths between 9,000 and 12,000 psi in dense Douglas-fir and southern pine. These values indicate strength ratios between 50 and 55 per cent of the controls. When tested in tension, softwoods usually break across the specimen at the finger tips rather than in the scarfed region of the joint, which indicates that stress concentrations still have an important influence on failure. In dense specimens of red oak and white ash, these joints yield average tensile strengths between 14,000 and 16,000 psi, which indicate strength ratios between 55 and 60 per cent in these species. These dense hardwoods tend to break in the scarfed regions of the joint, suggesting that not the tips but rather the scarfed regions have the most influence on failure.

The above-mentioned difference in manner of failure indicates that joint improvement should follow different patterns for softwoods and hardwoods. End-joints in structural softwoods can best be strengthened by further lessening the stress concentrations at the finger tips, whereas end-joints in dense hardwoods can best be strengthened by flattening the slope of the scarfed regions or by developing glues that produce scarf joints of greater strength.

The Auburn-Warner joint averages 7,300 psi in southern pine when tested in tension. The fact that this strength is lower than the above joints probably is due to the larger amount of cross-sectional area in truncated tips.

In designing fingered scarf joints, it is not yet known just what minimum tip thickness will stand up under production conditions or what maximum finger length is practical to use. Tips as thin as 0.040 inch have been used in production in this country. The Russians report[4] production use of tips as thin as 0.3 mm (about 0.012 inch), but the actual service records of such tips are not available. Although joints with fingers as long as 2¾ inches have been used, most manufacturers of clatterheads prefer that the fingers be 1¼ inches or less in length.

Factors Other Than Joint Design Which Affect Strength

Gluing Technique: The scarfed regions of an end-joint will absorb considerable glue under high pressure, and starved joints may result. Many resorcinol glues are rather low in viscosity and give trouble in this respect. Adequate open assembly time is necessary so that the glue may thicken somewhat prior to pressure application. Experience at Auburn also indicates that double spreading the end-joint is almost a necessity if high-quality joints are required.

Cross Grain: Tensile strength is extremely sensitive to cross grain. In serious research work, every effort should be made to eliminate cross grain steeper than about 1 to 50. (Such restrictions are, of course, impractical in production.) While the exact relationships have not been estab-

[3] Richards, D. B., and B. M. Cool. 1953. End-joints for southern pine. Agric. Exp. Sta., Ala. Polytechnic Inst. Leaflet 39. Auburn, Alabama.

[4] Pavlov, V. P. 1954. Joining wood longitudinally with toothed tenons. Translation No. 2705, CSIRO, Australia. Trans. from Derevoppererabatyvainshchaia I Lesokhimicheskaia Promyshlennost Vol. 3 (10):5-8.

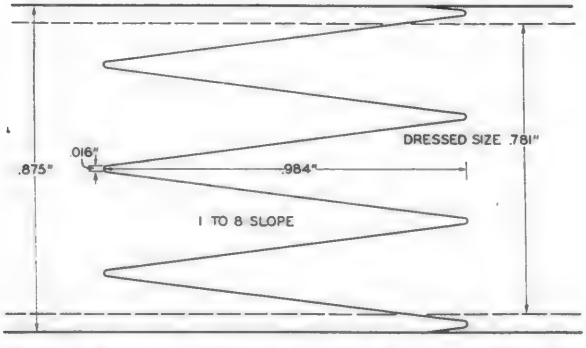

Fig. 4.—The Auburn E-joint as seen in edge view. This joint is similar in strength to the Auburn B-joint and will yield tensile strength values between 14,000 and 16,000 psi in dense white ash and red oak, and between 9,000 and 12,000 psi in dense Douglas-fir and southern pine.

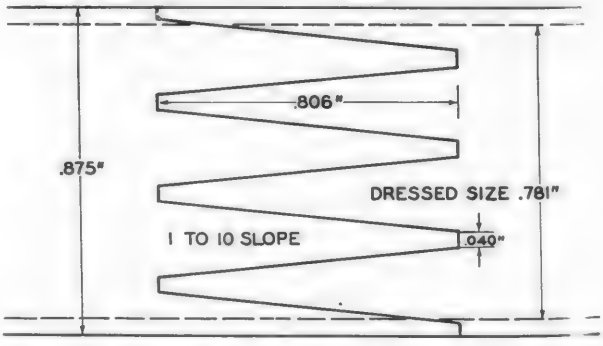

Fig. 5.—The Auburn-Warner joint as seen in edge view. This joint has a tensile strength of 7300 psi and a bending strength of 10,300 psi in southern pine.

lished, it seems probable that cross grain of a given severity weakens the clear wood controls more than it weakens the joints. This subject needs additional study to relate various research studies to each other and to the problem of establishing working stresses for end-jointed wood products. The cross grain problem becomes especially acute when lumber is upgraded by cutting out knots and end-jointing the remaining pieces. The severe cross grain around the knot remains, and there is little if any upgrading in strength. In removing a knot, the cut should pass at least one knot diameter away from the knot. For high-strength uses, even more exacting cutting rules may be required.

Annual Ring Orientation: Woods such as southern pine and Douglas-fir derive a considerable portion of their strength from the dense bands of summerwood, which usually occupy only 25 to 50 per cent of the cross section of the wood. This means in a randomly matched end-joint it is likely that over half the summerwood is actually glued to springwood. Hence, it could not be expected to yield full strength, even if the glue joint were 100 per cent effective in holding the summerwood in tension.

In research studies, end-joints have been produced in which the annual rings of the two pieces are perfectly matched, completely mismatched (all summerwood glued to springwood), as well as various intermediate conditions, such as half way matched, random matched, and cross-matched. The term cross-matched is used to describe joints produced when a piece with the convex (bark) side of the annual rings up is glued to a piece with the concave (pith) side of the annual rings up. The term has nothing to do with cross grain, but is used because the annual rings tend to crisscross at the joint in the bastard-sawn regions of a board so jointed.

Preliminary observation suggests a slight tendency for perfectly matched scarf joints to be stronger and cross-matched joints to be weaker than average. Random-matched, half-matched, and mismatched joints tended to be intermediate in strength. Detailed statistical analysis of more extensive data will be needed to establish these rather erratic relationships, but in the meantime, the investigator should be aware that ring orientation may have some influence on joint strength.

Strength of End-Joints in Beams

In many uses, wood is loaded as a beam. Hence, the strength of end-joints in bending is probably of more interest to many people than the tensile strength. However, since the stiffness and compressive strength of the better end-joints are the equal of clear wood, it turns out that the bending strength of one of these joints is largely dependent on its tensile strength. For shallow beams, the modulus of rupture (a measure of bending strength) of a fingered scarf joint will exceed its tensile strength in absolute value (Table 1). For very deep beams, the tensile strength and the modulus of rupture of a fingered scarf joint will probably be very similar in magnitude. For example, suppose an end-joint yields a strength of 11,000 psi in both tension and bending in a piece of southern pine that has a modulus of rupture of 15,000 psi and a tensile strength of 21,000 psi. Such a joint could be said to have a strength ratio of 52 per cent in tension and 73 per cent in bending.

Table 1.—TYPICAL VALUES FOR AVERAGE STRENGTH OF FINGERED SCARF JOINTS IN STRAIGHT-GRAINED, KILN-DRIED BOARDS OF DENSE GRADE

Joint	Type of wood	Tensile strength		Beam strength (modulus of rupture)	
		Pounds per square inch	Percent of controls	Pounds per square inch	Per cent of controls
Auburn E-joint	White ash	15,200	58	--	--
	Red oak	14,600	57	--	--
	Southern pine	11,200	53	12,600	77
	Douglas-fir	9,100	54	--	--
Auburn-Warner	Southern pine	7,300	34	10,900	70

Eventually, all joints should be evaluated for strength in both deep and shallow beams, and appropriate basic stresses should be derived after considering the variability inherent in the manufacturing process. In the meantime, however, it is believed that joints will be improved most rapidly by study of their tensile strength.

Improved Glues

The timber laminators want a glue with durability of a resorcinol but at the price of a urea. While no one expects such a glue to be on the market in the near future, it is hoped that eventually the glue makers will achieve this goal.

As a result of an increase in end-jointing, special end-jointing glues will probably be developed. Besides being strong and durable, such a glue should be formulated to control excessive penetration in the end grain of the end-joint.

MANUFACTURING METHODS

Only finger joints and fingered scarf joints will be considered in this section, since other types of joints at present do not interest lumbermen to any great extent.

Finger Joints and Fingered Scarf Joints

Joint Cutting: Joints of this type can be cut with a revolving cutterhead and a means of holding the wood firmly during the cutting operation. Most production-type machines, however, include a cut-off saw ahead of the revolving cutter as well as a means of clamping the wood firmly as it is passed by the cutter (or as is the case of one type of machine, the cutter is moved past the board). Such machines include single- and double-end tenoners, flooring end matchers, and special end-jointing machines. The production rate varies from one or two joints a minute on a hand-fed single-end tenoner, up to a potential production of 90 joints per minute on a pair of flooring end matchers. The latter high rate of production is never maintained, since it is common practice to slow these machines down to 50 to 60 lugs per minute. In addition, the operator often feeds only every other lug. This slow-down is caused by uneven supplies of material, plus the fact that the assembly and curing portion of most setups are not capable of keeping up with a sustained output of even 40 joints per minute. Even with a pair of end-jointing machines, most plants do not average much more than 10,000 board feet per 8-hour shift. If the average lumber short contains about 1 board foot (that is, a 3-foot 1 by 4 or a 2-foot 1 by 6) this means 10,000 joints per shift or about 21 joints per minute.

Since each time a board passes by the cutter a half-joint is cut (it takes two pieces to make an end-joint), it is clear that 21 joints per minute could be produced either by two machines each averaging 21 half-joints per minute or by one machine averaging 42 half-joints per minute. The latter system would, of course, require some efficient method of reversing the boards end for end and recycling them through the machine as well as the use of a "reversible joint" which will match to itself when turned over. Most operators find one end-jointing machine inadequate and eventually go to two machines to get a smooth flow of material.

Probably the largest market is awaiting the manufacturer who makes an efficient, low-cost end-jointing machine. A home-made machine that will produce about 500 board feet a day can be made by minor alterations in a single-end tenoner. Proper design by

a competent manufacturer should increase this figure to 1,000 board feet a day and still keep the price near the $3,000 mark. One manufacturer has already entered this low-cost market with a $3,500 machine designed to cut end-joints in 2,000 to 3,000 board feet of lumber per day.

Glue Spreading: In specially designed end-jointing machines, the glue is generally spread while in the machine either by a shaped roller or a shaped pressure glue gun. Care should be used with a glue gun, since the filler in certain glues may clog the holes in the gun.

In certain low-volume end-jointing operations, one or both of the members is simply dipped in the glue. This often leads to considerable waste of glue. A more desirable approach, even for the low-volume manufacturer, is to make a small glue wheel, shaped on a lathe to fit the finger joint.

Joint Assembly: Initial assembly is usually accomplished by hand pressure or by the pressure of differential feed rolls that operate by running the infed roll faster than the outfeed roll. It is usually desirable to follow this initial assembly by a positive end pressure of from 200 to 500 pounds per square inch of cross-sectional area. In softwoods, pressures as high as 800 psi should be avoided since they will cause splitting of the wood. This final pressure may be applied by mechanical, hydraulic, or air clamps, and should be accompanied by enough restraint on the face of the board to prevent buckling.

Production equipment is on the market today that will assemble end-jointed stock at 70 to 90 feet per minute, cut it to length with a flying cut-off saw, and apply final end pressure to the cut pieces by means of air clamps. Even this rate of production, however, would only produce 30 board feet per minute in a 1 by 4 stock. This means if there were absolutely no production delays or down time, the maximum production would be 14,400 board feet per 8-hour shift. In view of this fact, it is not surprising that 10,000 board feet a shift is considered good production for an end-jointing set up when the usual delays and down time are taken into consideration.

Pressing and Curing: The most common method of curing finger joints today is to allow them to cure at room temperature without any pressure being applied. For finger joints with thick tips at the surfaces, this technique works reasonably well since high strength cannot be expected of such joints anyway. For fingered scarf joints where appreciable strength is required, this method is generally unsatisfactory. The thin tips of the fingered scarf joint tend to spring outward at the surface and a poor bond often results at this most critical region. This poor joint at the surface is very damaging to both strength and appearance.

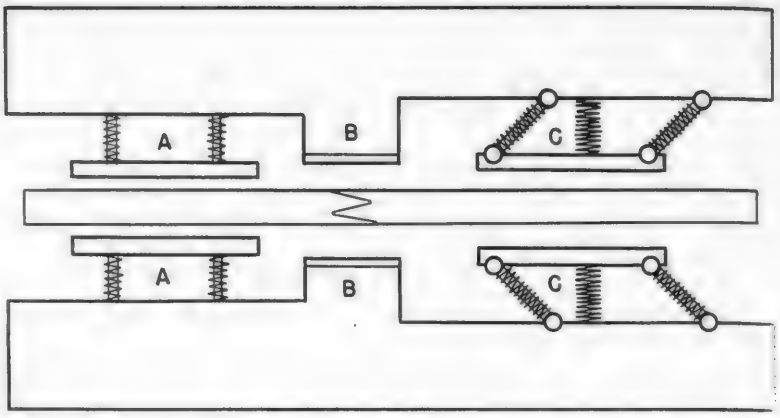

Fig. 6.—Diagram showing how a simple hot press can be used to force an end-joint together endwise just prior to applying top pressure. As the press closes, the plates at A grip the board; the plates at C then make contact and, due to their spring-loaded angular support, pivot toward the left and apply end pressure to the end-joint; the hot plates at B then make contact and cure the joint while applying top pressure.

Machines are available that cure the joints as the stock moves through a high-frequency radio field. Since adequate top pressure is generally not provided, this curing method has many of the shortcomings of room-temperature cure with the added problem that any slight working at the joint during cure may weaken the joint seriously. The main advantages of the radio-frequency equipment are that it may save storage space and perhaps saves extra handling.

If interested in high-strength fingered scarf joints, the prospective equipment buyer should base his production estimates on curing times of not less than 40 seconds. The type of cure that can be obtained in 10 to 20 seconds is generally a drying out of the glue without adequate chemical cure. Such a joint is not up to the rigid strength requirements of end-joints. Manufacturers who wish to use these fast curing cycles should run sufficient strength tests to make certain that they are getting an adequate type of cure.

Machines are also available that cure a single end-joint while it is held firmly in a radio-frequency press. This batch-type RF equipment can easily supply the necessary top pressure to insure a strong joint, but only by use of multiple units can high production be obtained. If each press unit could average one joint in 45 seconds, it would take 16 press units to keep up with a joint-cutting set up that averages 21 joints per minute.

A hot press can tack down the critical outer tips of a fingered scarf joint in 40 to 45 seconds, and the rest of the joint can cure at room temperature later. This technique works very well with properly designed joints in lumber thicknesses of one inch and less. With joints that fit perfectly, this technique can also be used with thicker wood. If for any reason the joints do not fit perfectly, however, there is more danger in thick pieces of one of the inner scarf joints opening up upon release of pressure and causing an imperfect joint. While the batch-type hot press has the same production limitations as does the batch-type radio-frequency press, the lower unit cost makes a battery of 16 small hot presses economically feasible.

An interesting feature of both the hot press and RF batch press is that the final end pressure can be applied by having grips on either side of the main press which grip the pieces of wood and force them together endwise just before the main press closes tightly (Fig. 5). The partly closed main press furnishes enough restraint to prevent buckling at the joint during the application of end pressure. Either of these batch presses could, of course, be oriented on edge so that the lumber travels along a narrow trough and passes through the press on edge.

One of the most promising press configurations is the continuous cross-feed press. In a press of this type, the material moves at right angles to its own length while the joint slides along between two pressure shoes. The heat may be supplied by heating the pressure shoes or by applying a radio-frequency field between them. While this type of equipment would be at a disadvantage in handling extremely long pieces, it is believed that pieces up to 16 feet or slightly longer could be produced on equipment of

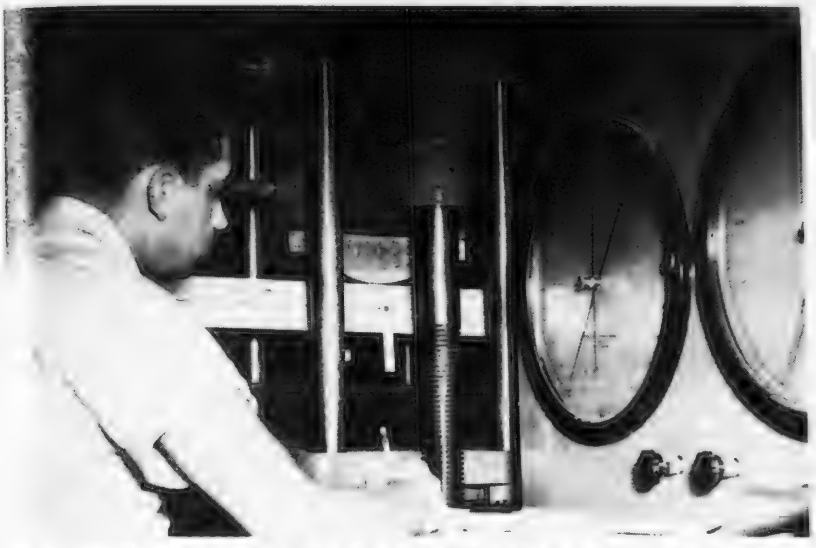

Fig. 7.—Testing an end-jointed 2 by 4 as a beam. The 2 by 4 is on edge, and the end-joint is at midspan directly under the loading head.

type. A heated shoe 7 feet long seems practical in such a set up. With lugs spaced 6 inches on center, the machine could be operated at 21 lugs per minute to give a 40-second cure to 21 joints a minute in narrow stock such as 1 by 4's. Wider boards would require a wider spacing of the lugs and a correspondingly lower number of joints per minute. While there are still technical details to be worked out on this type of machine, it holds considerable promise for a satisfactory production rate from a machine of reasonable cost.

For production of such items as laminated 2 by 4's, perhaps the simplest way to cure the end-joints is to cure them at the same time and by the same method as the main glue line of the lamination. The principal problem in such an operation is that a poorly fitting end-joint may tend to produce a gap in the main glue line of the lamination. An additional problem is glue squeeze-out on the outside face of the end-joint where no laminating glue line is intended. A piece of paper over the outside face of the end-joint controls this problem by preventing accidental lamination to the next 2 by 4.

Economic Aspects of End-Jointing

Theoretical analysis indicates that the total cost of end-jointing should be about 1½ to 2½ cents per joint in 1 by 4 lumber.[5] Only meager data are available from actual production operations, but these figures range from 1 cent to 4 cents per joint. If the average 1 by 4 short is about 3 feet long, then it seems that $15 per M might be a fair cost for an efficient operation. A decrease in the length of the average short or major work slow downs could easily increase this cost to $25 or $30 per M.

Some operators manufacture and sell sheathing grades of lumber by end-jointing and edge-gluing low grade shorts into panels 2 feet by 8 feet or into 16-foot boards 8 inches or wider. If sufficient premium is obtained for such a sheathing material, an operation of this type may be profitable. Normally, it would seem that the larger price differential would make it more profitable to produce finish-grade boards and panels by the same process. For example, one company is end-jointing and edge-gluing redwood into finish-grade panels 2 feet wide by 20 feet long. Another company is end-jointing and edge-gluing ash into clear panels about 3 feet wide and 8 to 12 feet long for remanufacture in their own operation. Both of these companies find their end-jointing operation very profitable.

Critical Developments

There are several developments that are especially important if end-jointing is to become well established in all phases of the lumber industry:

1. The lumberman must realize that there are important differences between different end-joints, different glues, and different glue-curing methods. Where strength and durability are of any importance, the lumberman should insist on, and the lumber grading rules should require, an adequate joint, an adequate glue, an adequate curing technique, and an adequate quality-control program.

2. A machine must be designed and manufactured that will cure an average of 20 or more joints per minute while holding about 150 psi pressure on the face of the joint.

3. Cutterheads must be improved so that end-joints with finger-tips as thin as 20 or 30 thousandths of an inch can be cut on production-type equipment without excessive dulling or burning at the tips.

4. An end-jointing machine must be designed and manufactured that will cut from 2 to 4 end-joints (from 4 to 8 half-joints) per minute and sell in the $3,000 bracket or less.

5. A batch-type hot press must be designed and manufactured that will apply final end pressure on the joint and then cure it under about 150 psi of face pressure on about a 45-second cycle. The press should cost between $1,000 and $1,500, and should be compact enough that it could be mounted in batteries of 4 to 8 presses within the reach of a single operator. This equipment plus the end-jointing machine in item 4 would allow the smaller operator to get into business with a reasonable capital investment.

Discussion

John Reno (Pacific Lumber Co.): When tested as a beam, are there failures in tension or compression?

Mr. Richards: Failures are always in tension. That is why we used the axial tension test in studying the joints.

Henry Huber (Dow Chemical Co.): What adhesive was used in the manufacture of the joints tested in tension and bending?

Mr. Richards: Urea, resorcinol, and some polyvinyl acetate; casein was not tried.

Mr. Huber: If internal stress is a factor in loss of strength of the finger joint, could the shrinkage of the adhesive upon curing be the cause of much of that stress?

Mr. Richards: It is the stress concentration in the wood beside the finger tips that seem to trigger the failure during testing. This is probably more a function of the elastic properties of the wood, plus the shape, size and spacing of the tips, than it is of shrinkage stresses in the glue line, but we know so little about this subject that it is rather difficult to be positive concerning the exact importance of each of these factors.

James F. Hamilton (Michigan College of Mining and Technology): How long in advance of actual gluing can the machining operation be safely conducted so that dimensional changes will not hinder good gluing operations? Please comment on both hardwood and softwood lumber.

[5] Richards, D. B. 1954. Salvaging lumber ends by end-jointing. Jour. Forestry 52:739-

Mr. Richards: No study of this was made. In actual production, however, only minutes elapse between machining and gluing.

Mr. Hamilton: Would there be a limitation if a substantial time lapse did occur?

Mr. Richards: Hardwoods, I would say are extremely critical. Softwoods, a little less critical, but I would not wait more than a day or so before gluing. Hardwoods give higher absolute and higher percentage strength.

F. L. Brown (Dow Chemical Co.): Is wood of adequate slope of grain for research purposes available for purchase from Alabama Polytechnic Institute? I am interested in obtaining both southern pine and yellow gum.

Mr. Richards: No, we would not be in a position to supply such material for sale. As a word of warning, most gum has such an interlocked grain that absolutely straight grained material is impossible to fabricate.

Peter Johnson (California Redwood Assoc.): Varied specific gravity of redwood causes difficulty in selecting glue viscosity. Using an average viscosity for average specific gravity, a low specific gravity piece will have a starved joint, and a high specific gravity piece will have an excess of glue.

R. W. Peterson (Canadian Forest Products Laboratories): The speaker found that rapid cures did not develop sufficient strength. Was this strength referred to immediate strength, or was it found that these rapidly cured joints do not eventually develop full strength?

Mr. Richards: All these joints were tested subsequent to a room-temperature after-cure of at least two weeks. Evidently the too-rapid cure had damaged the joint beyond repair.

J. M. Sayward (Vermont Bureau of Industrial Research): To better utilize wood by gluing, could warped billets be face glued with alternate bend and alternated with straight pieces; then laminated boards cut from the whole, or would these resawed boards develop S-shape cross-section due to strain?

Mr. Richards: We have not studied this factor specifically. A bowed 1 by 4 laminated to a straight 1 by 4 will produce a 2 by 4 with about ½ of the original bow. Opposite bows will, of course, tend to cancel each other. When many laminations are included in one timber, the warpage in any one lamination has very little influence on the large timber.

J. M. Richolson (Material Laboratory, N. Y. Naval Shipyard): Are you planning to investigate the strength of the various designs in finger joints after they have been subjected to some type of accelerated weathering or cycling, particularly with respect to mating tangentially and radially oriented boards?

Mr. Richards: This is a very important subject. While our long-range plans call for such a study, we may not get to it in the immediate future. If anyone is specifically interested in such a study we might be able to work out a cooperative approach to the subject.

Differentiation of Sapwood and Heartwood in Western Hemlock by Color Tests

H. W. EADES

Vancouver Laboratory, Forest Products Laboratories of Canada, Department of Northern Affairs and National Resources, Vancouver, British Columbia

Perchloric acid, iron salts, and ammonium bichromate were found to be of value in differentiating sapwood and heartwood in western hemlock. Other indicators found effective on other softwood species are listed. Sapwood 5 inches thick may be found in western hemlock trees 20 inches in diameter.

IN MOST SOFTWOOD SPECIES, the limits of sapwood and heartwood are generally quite apparent to the eye on a newly cut cross-section. Characteristically, the area comprising the outer annual rings next to the bark is yellowish or creamy white in color, in contrast to the darker core of heartwood. The line of demarcation is usually quite abrupt, except at the lower extremity of the trunk.

Western hemlock is an exception to this general rule. No natural sapwood-heartwood line exists in this species, and it is held by some that Western hemlock does not possess true heartwood. Although the wood is being used to an increasing extent for structural timbers and for railway ties and poles, it has not been classed among the more durable woods, and the present practice is to impregnate it with preservatives when it is to be subjected to conditions that favor decay. Since pressure-treating specifications (12)[1] recommend that, in structural timbers and railway ties, at least 90 per cent of the sapwood should be impregnated, it is important to know if the sapwood of hemlock can be readily differentiated from heartwood, and, if so, how.

For many years, search has been made, with varied success, for chemical indicators which, when applied to cross-sections of wood, would produce color differentiation between sapwood and heartwood. While information has been published on indicators applicable to a number of softwoods (2, 6, 7, 8, 9, 10, 11) none has hitherto been recommended as effective on western hemlock. Accordingly, experimentation was undertaken at the Vancouver Laboratory of the Forest Products Laboratories of Canada to try to find a satisfactory sapwood-heartwood indicator for use on this wood.

Experimentation

In all, over 200 chemicals or combinations of chemicals were empirically tested. These included: 1) starch indicators, 2) organic dyes and pH indicators, 3) sugar test solutions, and 4) miscellaneous chemical reagents.

The routine procedure was to apply each test solution to cross-sections of the wood in a series of contiguous drops, and then to observe and time any color changes in the indicator. For the initial tests, only seasoned wood was used, but the successful indicators were also tested on green wood and on wood wet through prolonged immersion in sea water. Discs of Douglas-fir, which usually has well differentiated sapwood and heartwood, were used for control tests.

The Author: H. W. Eades is Head of the Wood Pathology Unit of the Vancouver Laboratory, Forest Products Laboratories of Canada. He received a BS degree in forestry from the University of Washington in 1922, and joined the Vancouver Laboratory in 1923. He is the author of several publications.

[1] Numbers in parentheses refer to the Literature Cited at the end of this paper.

Table 1.—SAPWOOD–HEARTWOOD INDICATORS

Indicator	Wood species on which effective	Color reaction
Perchloric acid (30 to 40 per cent solution on seasoned wood, 40 to 50 per cent solution on green or wet wood)	Western hemlock True fir Douglas-fir Lodgepole pine Sitka spruce Western red cedar	Requires caution in use. On dry wood: Sapwood light green Heartwood intense green On green wood: Sapwood pink or mauve Heartwood generally brown
Iron salts 1/10 N. Ferrous sulfate Ferric nitrate Ferrous ammonium sulfate	Western hemlock True fir Douglas-fir	Sapwood dark blue Heartwood light blue (or the reverse may occur)
Benedict's solution, or Fehling's solution	Douglas-fir Sitka spruce Western red cedar	Sapwood blue-green Heartwood chocolate-brown
Ammonium bichromate (4 to 8 per cent in water)	Douglas-fir Western hemlock* Western red cedar	Sapwood pale orange Heartwood dark brown
Iodine (2½ per cent solution in water)	Douglas-fir	Sapwood blue (if starch present)† no reaction on heartwood
Potassium iodide (2 per cent) plus iodine (2 per cent in water)	Douglas-fir	
Bromcresol green (1 per cent) in water solution	True fir Douglas-fir	Sapwood yellow Heartwood green
Bromcresol green (1 per cent) in alcohol solution	Douglas-fir	
Bromphenol blue (1 per cent). Slightly acidified Bromphenol blue (1 per cent)	True fir Douglas-fir	Sapwood pale brown Heartwood dull blue
Methyl orange (1 per cent) either in water or alcohol solution	Douglas-fir	Sapwood red Heartwood orange

*Result not always reliable on this species.
†Occasionally, starch is absent in the sapwood of Douglas fir, therefore a negative reaction to iodine does not always mean that the wood tested is heartwood.

Starch Tests: Starch occurs in the living cells of the sapwood in many wood species, and it is now generally accepted that the formation of heartwood and its usually accompanying change of color is due to the transformation of starch into tannins and similar bodies (1, 3). A simple starch indicator such as iodine, therefore, which turns starch grains a blue color, would indicate, in the event of positive results, that the blued wood was sapwood. At the same time, it was realized that absence of starch does not necessarily mean that the wood is heartwood. Although starch is often found in the sapwood of many wood species, it is by no means invariably present. The starch reserve may have become depleted, it may be wholly or partly transformed into soluble sugars during the growing season and consumed in the living tissues, or it simply may not be present at all in certain sections of the tree (1).

In the case of the western hemlock specimens tested, no starch reaction was apparent on the test pieces after application of 2½ per cent iodine in water solution, or 2 per cent potassium iodide added to 2 per cent iodine. This result was a repetition of previous experience with this wood, and starch seems to be rarely detectable in it, or only sparsely distributed, so that the iodine test is of no value as a sapwood indicator in this case. The relative absence of starch in the sapwood of western hemlock may explain the absence of tannins or coloring matter in the heartwood of this wood.

A typical blue reaction was obtained on the sapwood of Douglas-fir specimens, and iodine can be assessed as a useful sapwood indicator in the case of this species.

Organic Dyes and pH Indicators: No positive results were obtained with organic dyes applied in solution to the wood, nor was the nigrosine test suggested by Hunt and Garrett (4) and mentioned in a report by a committee of the American Wood Preserver's Association (11), found to be effective.

The difference in acidity between the heartwood and sapwood of western hemlock was so slight that no reliable color differences were recorded when pH indicators werer applied.

Bromcresol green, bromphenol blue, and methyl orange, either in water or alcohol solution, produced clear-cut color changes between sapwood and heartwood of Douglas-fir.

Sugar Test Solutions: The formulae for the two sugar test solutions used are:

Benedict's Solution

Sodium carbonate—100 grams
Sodium citrate—173.8 grams
Copper sulfate—17.3 grams
Distilled water—Enough to make 1 liter of solution

Fehling's Solution

Part A. Copper sulfate — 34.64 grams; Distilled water—one-half liter

Part B. Sodium hydroxide — 60 grams; Rochelle salts—173 grams; Distilled water—one-half liter

When Fehling's solution is used for sugar analysis, the parts A and B are kept separate. For sap-heart determinations, the two parts may be mixed together, and the mixture retains its effectiveness indefinitely.

On western hemlock, Benedict's solution and Fehling's solution did not produce results sufficiently clear or consistent to warrant recommending these standard sugar indicators for routine use. Each solution produced an instantaneous and well-marked differentiation on Douglas-fir. The treated portion of the heartwood turned a rich chocolate-brown and the sapwood turned blue-green. The color reaction remains obvious on the test pieces for many months. All the specimens were seasoned, winter-cut wood.

Miscellaneous Chemical Reagents: *Ammonium bichromate* produced excellent sapwood-heartwood differentiation on both seasoned and green borings taken at monthly intervals from Douglas-fir trees in the course of a year. Concentrations of from 4 to 8 per cent of the salt in water turned the heartwood a very dark brown and the sapwood a pale orange. On similar borings of western hemlock it was found fairly effective. It is noteworthy that an investigating committee of the A.W.P.A. (11) reported "fair" results with this reagent on western hemlock.

Perchloric acid, an oxidizing agent, was the most generally effective indicator tested. It provided sapwood-heartwood differentiation on western hemlock as well as on a number of other softwood species. On seasoned wood, a 35 to 40 per cent solution, when applied to a cross-section or to small cylinders bored from the wood, gave, within 5 to 20 seconds, a light green coloration to the sapwood and a bright, intense green color to the heartwood. With green or waterlogged wood, a slightly stronger concentration, 45 to 50 per cent, was required. The color differentiation shown upon salt-water soaked wood was similar to that shown upon seasoned wood, but when the test pieces were in the green condition, the sapwood was usually colored pink or mauve (pale bluish-purple), and the heartwood, instead of being intense green, was brown. The color differentiation was abrupt and easily distinguished.

The oxidation reaction usually will continue until the treated portion turns black, but the color differentiation will remain apparent for 40 to 60 minutes with seasoned wood, and may last for some days if the wood is tested while still green.

On western hemlock and true fir borings from standing trees, perchloric acid showed a sapwood depth varying from 2½ to 5 inches in western hemlock trees of from 15 to 20 inches in diameter at breast height, and from 3

to 4½ inches in true fir trees about 24 inches in diameter. This is a high proportion of sapwood, but the results were confirmed with iron salts, and, since perchloric acid was a reliable indicator on other woods in which a natural sapwood-heartwood line shows clearly, it was assumed that the color differentiation in the hemlock and true fir specimens indicated a sap-heart line.

Perchloride acid should always be treated with care. It is best not to keep more than one pound of the *concentrated* acid in any plant or laboratory at one time, because, in this form, it can be highly explosive when contaminated with organic materials. In the dilute form suggested for use, its explosive propensities are practically nil, but it should be kept away from sources of heat. The eyes, hands, and clothing of anyone handling the acid should be protected.

Iron Salts: Ferrous sulfate, ferric nitrate, or ferrous ammonium sulfate, when used as 1/10 N. solutions, produced a dark-blue and a light-blue sapwood-heartwood differentiation on western hemlock. For some unexplained reason, the colors were reversible with different samples of the wood, that is, wood from one tree showed a dark-blue sapwood and another, light-blue, but in every case, one or the other type of color reaction appeared and the sapwood-heartwood line was delineated.

With true fir, a similar color differentiation was obtained, though not quite so contrasting as in western hemlock. The color contrast was especially noticeable in the case of Douglas-fir.

The contrast shown by the iron salts was not so marked as it was with perchloric acid, but these salts are superior to the acid from a practical viewpoint in that they are neither caustic nor combustible. The reaction is inhibited when the wood is very wet.

Results

The main purpose of the study was to see if the limits of sapwood and heartwood in western hemlock could be distinguished colorimetrically with various chemical indicators.

Indicators that produced colorimetric differentiation between sapwood and heartwood, and that are sufficiently reliable to be recommended for use on western hemlock, are perchloric acid, certain iron salts (ferrous sulfate, ferric nitrate, and ferrous ammonium sulfate), and ammonium bichromate (11). In the case of the last named, the differential color reactions were sometimes less accentuated than those obtained with the other two compounds. Use of these indicators showed that the proportion of the log cross-section occupied by the sapwood may be very considerable—up to one-quarter of the diameter.

True fir (amabilis and grand firs), in common with western hemlock, has no naturally demarcated sapwood-heartwood line. Because it has less strength than does western hemlock, it is seldom treated with preservatives and used in structural situations, and consequently location of the sapwood-heartwood line in this species is seldom required. Application of the colorimetric agents (see Table 1), perchloric acid, iron salts, and the pH indicators bromcresol green and bromphenol blue (5), to cross-sections of this wood showed that true fir possesses a high proportion of sapwood, approximately the same as that of western hemlock.

All the above-mentioned reagents were tested and proved satisfactory on Douglas-fir specimens either with or without a well demarcated sapwood-heartwood line. This procedure can be construed as a control or check on the findings in connection with western hemlock and true fir.

In addition to those mentioned in the preceding paragraphs, other indicators found sufficiently reliable on Douglas-fir were Benedict's solution, Fehling's solution, ammonium bichromate, iodine, and iodine with potassium iodide, as well as methyl orange and some other pH indicators (see Table 1). Since Douglas-fir occasionally has a sapwood-heartwood line that is indistinguishable, and since it may at times contain internal sapwood, these indicators may be found useful on this wood.

Perchloric acid, Benedict's solution, Fehling's solution, and ammonium bichromate also produced good results on western red cedar. Perchloric acid (35 to 45 per cent solution) is a good general indicator on several species, but it must be handled with care and is not too suitable for other than laboratory use by technicians.

There is a general tendency for indicators to produce more marked color differences on dry wood than on unseasoned wood or wood saturated with sea water. In some cases, there is a time lag of 20 minutes or so before a color difference becomes apparent on wet wood. A smooth surface gives a better indication than a rough surface, and, in general, the highest sensitivity to color indicators is attained when application is to wood that has been cut during the growing period.

With the possible exception of perchloric acid, not one of the named indicators is infallible—on hemlock or any other wood. For this reason, the use of more than one is recommended as a check.

The effective sapwood-heartwood indicators discovered in the course of the work, together with the proportions in solution and the wood species to which may be applied, are listed in Table 1.

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Distribution of Fungicidal Extractives in Target Pattern Heartwood of Western Red Cedar

H. MacLEAN
and
J. A. F. GARDNER

Vancouver Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources

Analysis of the natural preservative content in "target pattern" heartwood by chemical methods indicates that the internal white rings are chemically related more closely to sapwood than to heartwood, and are deficient in fungicidal extractives. These results are consistent with the lower decay resistance of these bands in poles in service.

THE DISTRIBUTION OF THE FUNGICIDAL extractives of normal heartwood of western red cedar *(Thuja plicata* Donn.) in relation to position in the tree and its variation with color has been described in detail in a previous paper[1].

The present paper discusses one type of abnormal heartwood color variation found in some stands of western red cedar in the southeastern corner of British Columbia and an adjacent area in the United States. This color variation consists of alternate concentric bands of light-colored and brown-colored wood, as seen in cross-section (Fig. 1). It is perhaps best described as an "archery target" pattern. In some trees, the bands are only arcs of circles and not complete rings. While the bands tend to follow the annual rings generally, they occasionally cross over the growth rings as they increase or decrease in width, similar to the manner in which the normal heartwood-sapwood boundary does not always follow a single growth ring.

In this material, the light zones are similar in appearance to sapwood, being almost white, and are readily distinguishable from normal heartwood, which exhibits a light straw color. These zones are sometimes referred to as "internal" or "included" sapwood.

Methods of Analysis

Cross-sections 2 inches thick from two poles were sampled by separating the color zones as carefully as possible with a band saw. After they were ground in a small Wiley Mill, duplicate 2-gram samples, where sufficient material was available, were analyzed for percentage soluble in hot water, thujaplicin, and water soluble phenols as outlined in the previous paper.

Results

The first cross-section (Fig. 1) was from the butt on an 11½-inch-diameter pole from Cranbrook, B.C., 92 years of age, with 75 years of heartwood that contained three rings of light-colored wood (samples 4, 6, and 10, Fig. 1) in addition to the normal sapwood (sample 1). Samples 9, 11, 12 and 13 were a tan to medium brown color (7.5 YR 6.5/5),[2] while

[2] Munsell book of color. Pocket Edition. Munsell Color Company, Inc. Baltimore (1929–42).

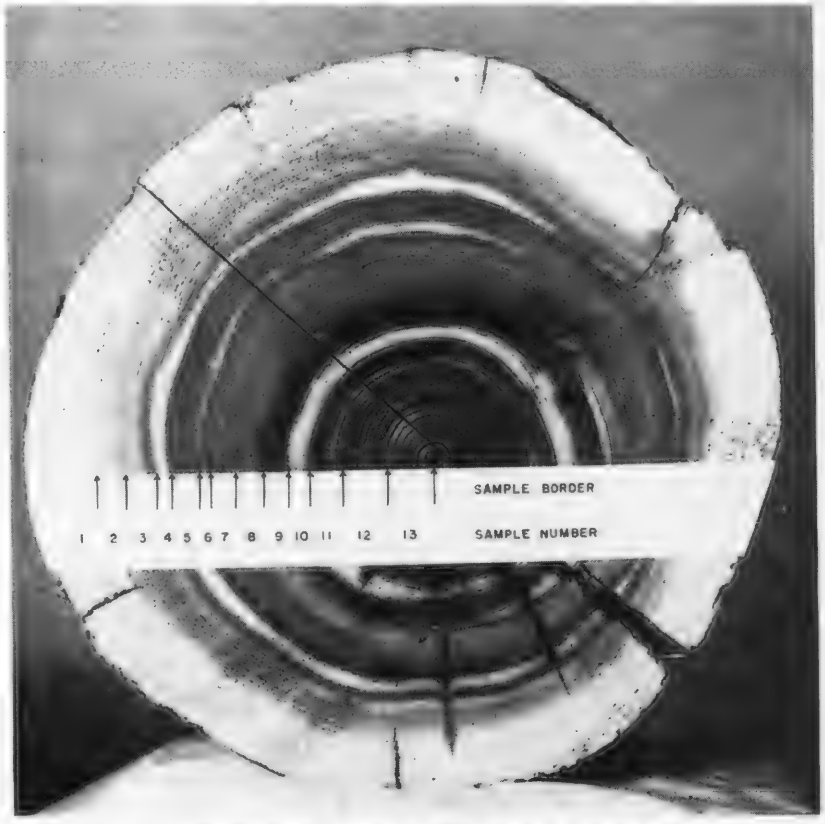

Fig. 1.—Cross-section No. 1 showing target pattern in western red cedar.

[1] MacLean, H., and J.A.F. Gardner. 1956. Distribution of fungicidal extractives (thujaplicins and watersoluble phenols) in western red cedar heartwood. Forest Prod. VI(12): 510–516.

The Authors: H. MacLean has been a research chemist at the Vancouver Laboratory since graduating from the University of British Columbia. He received a BA in 1947 and a MA in 1948 in Honors Chemistry.

J. A. F. Gardner has been head of the Wood Chemistry Section at the Vancouver Laboratory since 1947. He received BA and MA degrees in Honors Chemistry from the University of British Columbia, and a PhD in organic chemistry from McGill. He formerly was a research chemist with Howard Smith Paper Mills, Cornwall, Ont.

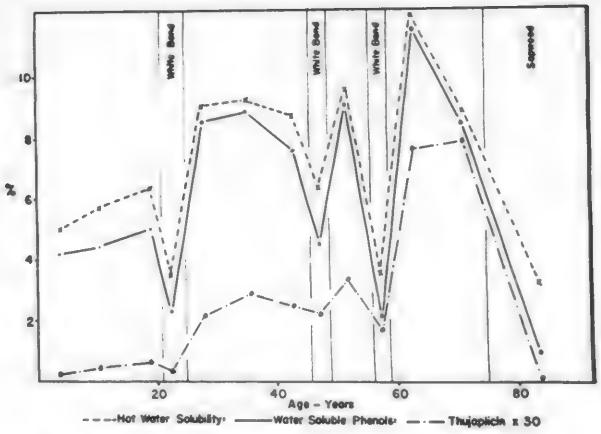

Fig. 2.—Variation of extractive content in white bands and normal-colored heartwood of target-pattern western red cedar, cross-section No. 1.

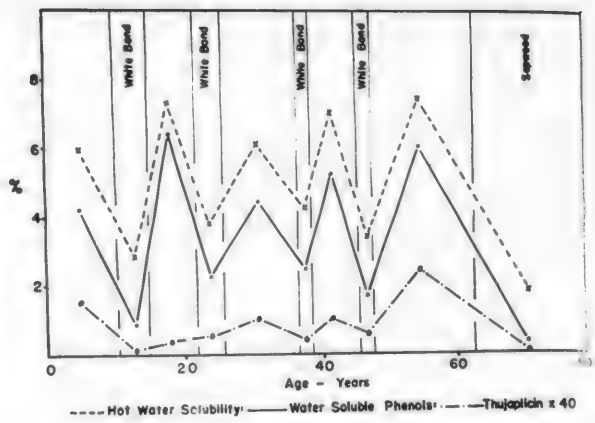

Fig. 3.—Variation of extractive content in white bands and normal-colored heartwood of target-pattern western red cedar, cross-section No. 2.

the remaining samples 2, 3, 5, 7, and 8 were a light tan color with a slight pinkish tint, (7.5 YR 7.5/4 to 5.0 YR 7.5/4) a typical cedar heartwood color. The results of the chemical analyses are given in Table 1 and graphed in Fig. 2.

The second cross-section, a pole top from Idaho (supplied by Professor H. D. Erickson, College of Forestry, University of Washington), had a diameter of 8½ inches with 63 years of heartwood and 79 growth rings. The heartwood was mainly medium brown (7.5 YR 6.5/5) with four internal, narrow concentric bands of almost white wood, samples 3, 5, 7 and 9, respectively. One of the brown zones, sample 8, was much darker (7.5 YR 5.5/4) than the others. Results on this cross-section are shown in Table 2 and are graphed in Fig. 3.

Discussion and Conclusion

Western red cedar heartwood has a high hot-water solubility and is rich in the natural preservatives, thujaplicins and water soluble phenols, and consequently has a very high decay resistance. The above results for the normal pinkish tan to medium brown colored heartwood samples are comparable to the results obtained in the previous paper[1] for pole trees of a similar age class. The low thujaplicin content of sample 8, cross-section 2, is consistent with dark brown zones in previous samples of this color heartwood found near the pith of normal trees.

On the other hand, cedar sapwood has a low hot-water solubility, is devoid of the fungicidal extractives (sample 1, Tables 1 and 2), and hence for cedar has a low order of decay resistance.

Comparison of the light-colored heartwood zones with normal heartwood and sapwood in Tables 1 and 2 and Figs. 2 and 3 clearly indicates that these zones are more closely related chemically to sapwood than to heartwood. In the wider light-colored zones where no overlapping difficulties in sampling were met (samples 4 and 10 of cross-section No. 1), the chemical relationship to sapwood is most apparent. The hot-water solubilities are identical with sapwood (approximately 1/3 the hot-water solubility of the adjacent heartwood), and the thujaplicin and water-soluble phenol content is in the same low range (less than 1/3 as much of the adjacent heartwood sample).

Englerth and Scheffer,[3] and Scheffer,[4] as a consequence of field stake tests and laboratory soil block experiments, conclude that the white rings of "archery target" cedar have as low a resistance to decay as cedar sapwood. This low resistance to decay is confirmed by pole users, who state that the pattern of decay is longitudinal along the white rings.

The target ring pattern has also been observed in western larch[5] and Douglas-fir. In the case of Douglas-fir, chemical findings similar to those reported here have been obtained by Kennedy and Wilson[5]. By chemical analysis, the included "sapwood" bands were found to be deficient in taxifolin, an important heartwood constituent.

In consideration of the above chemical results, as well as the known decay pattern of "archery target" western red cedar, the terms "included" or "internal" sapwood appear justified.

The reason for this development of "target ring" heartwood sapwood zones in trees of certain interior areas is not known. Whether it is due to an uncontrollable factor such as severe local climatic conditions or some other mechanism such as fungal action which might be controlled should be investigated.

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Table 1.—ANALYSIS* OF CROSS-SECTION NO. 1

Sample No.	Growth rings	Hot water sol.		Thujaplicin		Water-sol. phenols	
		Brown %	Light %	Brown %	Light %	Brown %	Light %
1 (sapwood)	75–92	----	3.26	----	0.000	----	0.9
2	67–75	8.58	----	0.27	----	8.6	----
3	59–67	11.97	----	.26	----	11.8	----
4	56–59	----	3.60	----	.063	----	2.1
5	49–56	9.55	----	.11	----	9.2	----
6	46–49	----	6.35	----	.075	----	4.5
7	40–46	8.64	----	.083	----	7.5	----
8	32–40	9.20	----	.093	----	8.9	----
9	25–32	9.00	----	.072	----	8.7	----
10	21–25	----	3.53	----	.009	----	2.3
11	16–21	6.30	----	.016	----	5.0	----
12	7–16	5.70	----	.010	----	4.4	----
13	1–7	5.00	----	.006	----	4.2	----

*Percentages are based on moisture-free wood.

Table 2.—ANALYSIS* OF CROSS-SECTION NO. 2

Sample No.	Growth rings	Hot water sol.		Thujaplicin		Water-sol. phenols	
		Brown %	Light %	Brown %	Light %	Brown %	Li
1 (sapwood)	63–79	----	2.82	----	0.000	----	0
2	48–63	7.37	----	0.061	----	6.0	
3	46–48	----	3.42	----	.015	----	1
4	39–46	6.99	----	.025	----	5.2	
5	37–39	----	4.25	----	.011	----	2
6	26–37	6.10	----	.025	----	4.4	
7	22–26	----	3.82	----	.014	----	2
8	15–22	7.34	----	.009	----	6.4	
9	11–15	----	2.81	.004	----	----	0
10	1–11	5.96	----	.038	----	4.2	

*Percentages are based on moisture-free wood.

Effect of Tension Wood on Seasoning and Machining of Eastern Cottonwood[1]

WENDELL P. CLARK

Graduate Student[2], Forestry Department, Iowa State College, Ames, Iowa

Compared to boards of normal wood, boards that contained tension wood bowed more, had more projecting fibers when planed, checked more, and had more projecting fibers along sawed edges. Areas of projecting fibers were closely associated with deviation of the grain in tension wood. Chip marking decreased with increased moisture content at the time of planing.

COTTONWOOD IS A RAPIDLY GROWING mid-western tree that is particularly well adapted to areas that are frequently flooded. It presents a means of getting greater returns from this type of sub-marginal land.

Difficulties have been experienced in seasoning and machining cottonwood lumber. Boards often show fuzzy areas of projecting fibers, and bind against the saw when cut. Other defects that cause trouble in cottonwood are bowing, crooking, cupping and twisting. An abnormal tissue, known as tension wood, is thought to cause the fuzzy areas of projecting fibers and many other problems common in processing cottonwood lumber.

Tension wood is found on the upper side of leaning hardwood trees. The fibers comprising this tissue differ from normal wood fibers in possessing a thick gelatinous inner layer of the secondary cell wall. These gelatinous fibers are associated with excessive longitudinal shrinkage, and they resist being severed when the wood is machined.

It would seem that this thick gelatinous inner layer would resist moisture movement during drying, but Marra (3)[3] found that drying in hard maple proceeds faster in gelatinous-fibered tension wood than in normal wood. Pillow (4) reports that heartwood in aspen, cottonwood, oak and willow shows more tendency to collapse in tension wood areas. Pillow also found that pieces of wood that contain both tension wood and normal wood tend to warp as a result of internal stresses caused by inherent differences in longitudinal shrinkage. Rendle (6) traced honeycombing in kiln-dried chestnut to excessive shrinkage of zones of gelatinous fibers.

Rendle (6) describes the rough, woolly finish of rip-sawed, planed, recessed, lathe-turned or molded tension wood surfaces as resembling a pile carpet. Lathe shavings from beech tension wood came off in long unbroken ribbons, whereas those of normal wood were short, brittle chips. Clarke (1) found that gelatinous fibers cause more severe fuzzy surfaces on green lumber. Marra (3) reports that green maple containing tension wood "worked" and "squirmed" while being sawed, as latent stresses were relieved in the wood. These stresses often caused the wood to bind against the blade with force sufficient to stop it. Davis (2) found that planing tension wood lumber with the grain reduced the amount and severity of projecting fibers.

The objective of this investigation was to make an evaluation of the effects of tension wood on the seasoning and machining properties of Eastern cottonwood.

Procedure

Selection of the tree: The tree selected for study was grown in south central Iowa. It was 22.2 inches in diameter (breast high), 95 feet in total height, 42 years old, and leaned 7 degrees and 34 minutes from the vertical. It was cut into four logs: A, B, C, and D, with the butt log designated as A. The logs were bucked and sawed into lumber the same day, with a total yield of 433 board feet. The lumber was then graded and stacked for air seasoning.

Seasoning: After nine months of air seasoning, the stack was dismantled and each board was measured for bowing, crooking and cupping. Bowing was measured by stretching a cord tautly between the ends of the board on the concave side and measuring the maximum deviation from this line. Crooking and cupping were measured in a similar manner.

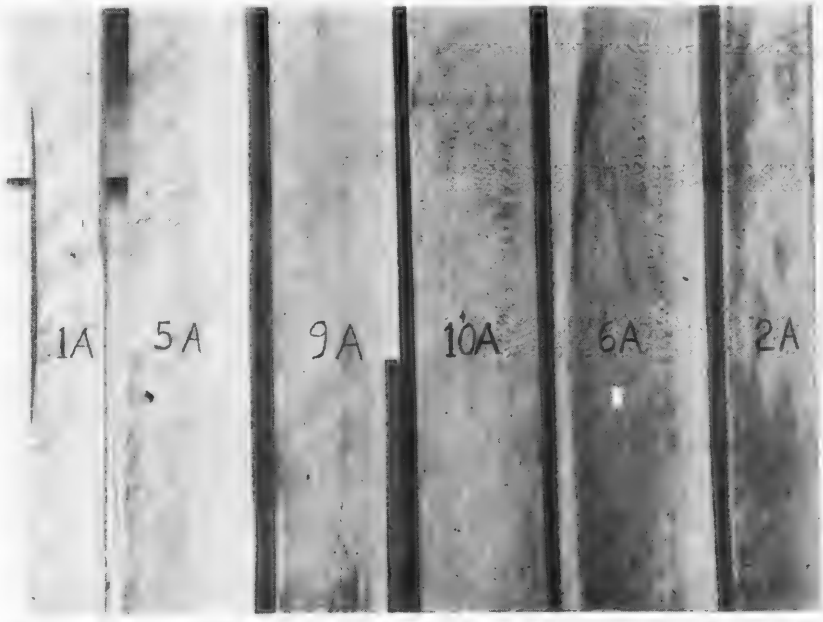

Fig. 1.—Of these boards from the butt log, the three on the right contain tension wood; those on the left are normal wood.

[1] Journal Paper No. J-3045 of the Iowa Agricultural Experiment Station. Project No. 1330.

[2] This work was done at Iowa State College as part of the requirements for the degree of Master of Science.

[3] Numbers in parentheses refer to Literature Cited at the end of this paper.

The Author: Wendell Clark received a BS in Forestry from Iowa State in 1952. He returned in 1955 and received a MS degree in wood technology in 1956.

Moisture content and casehardening samples were taken 29 inches from the end of each board. The average, shell, and core moisture contents were determined by oven drying. The extent of casehardening was evaluated by visual examination of standard 2-pronged samples.

The lumber was then kiln dried at the U. S. Forest Products Laboratory. It was dried from 13 to 8 per cent moisture content, and conditioned to remove internal stresses according to the Laboratory's new kiln schedules (7). Measurements of bowing, crooking and cupping were made on the kiln-dried lumber by the same procedure used for air-seasoned lumber.

Machining: The one-inch lumber was sawed into 4.5 by 37 inch boards for the machining studies. These pieces were selected so as to exclude large knots, severe cross grain, and large splits. Twenty boards were chosen to include maximum amounts of tension wood as indicated by projecting fibers, and 20 were selected with smooth surfaces to represent normal wood. The forty samples were then surfaced to bring them to a uniform thickness.

The machining tests were made at wood moisture contents of 6, 12, and 18 per cent. At each of these moisture contents, all boards were given a 1/32 inch surfacing cut on both faces and a ¼ inch saw cut on one edge. The pieces were then graded for roughness, chip marks, and checking. The sawed edge was graded for severity of projecting fibers. The following system of grading was used:

1. free from defect
2. light defect
3. moderate defect
4. heavy defect

The humidity chamber used to condition the matching samples was designed and built at Iowa State College. A 5 by 13 inch Delta thickness planer was used for surfacing. The cutterhead of the machine has three knives, a cutting-circle diameter of 2 9/16 inches, a cutting angle of 30°, and a clearance angle of 23°. The knives were lightly jointed before they were used to give a jointed heel of about a 1/64 inch. The machine has a feed rate of 14 feet per minute, makes 75 knife cuts per inch, and has a cutterhead speed of 4200 rpm.

An 8-inch, tilting arbor saw was used for the sawing studies. The blade was a Lemmon and Snoap alternate-bevel, 8-inch miter saw. It has 40 carbide-tipped teeth in groups of five, including one raker and four alternate-beveled cut-off teeth. The cut-off teeth have a hook of approximately 10° and a tip bevel of 20°, but no face bevel.

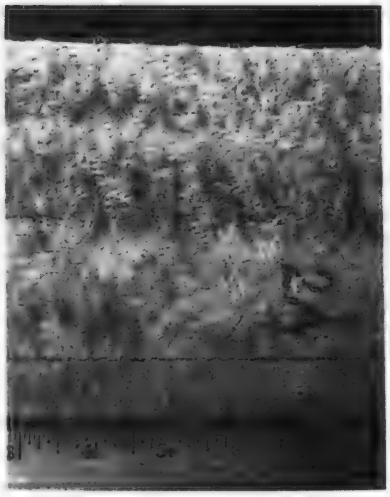

Fig. 2.—Dense area of projecting tension wood fibers.

The raker teeth are flat, approximately 0.015 inch below the cut-off teeth, and have a hook of approximately 20°. The saw cuts a kerf of 0.110 inch and has an arbor speed of 4100 rpm, which results in a peripheral speed of 8600 feet per minute. The saw was hand fed as uniformly as possible at a rate of approximately 35 to 40 feet per minute.

Results

In the seasoning studies, wood from the upper side of the leaning tree was considered to be tension wood, and that from the lower side normal wood. In another study, Wahlgren (8) made a microscopic analysis of a sample from each of the boards used in this study. He found an abundance of gelatinous fibers in all samples from the upper side of the tree, while gelatinous fibers were absent or very sparse in samples from the lower side of the tree. He found a strong correlation between the frequency of gelatinous fibers and the abundance of projecting fibers. Since wood from the same boards were used in both studies, it seems logical in this study to consider the wood from the upper side of the tree as tension wood and that from the lower side as normal wood.

No severe tendency of the boards to bow away from or pinch the saw was noticed as the green logs were milled. Boards from the upper side of the tree showed areas of fuzzy projecting fibers, as can be seen in Fig. 1. Fig. 2 shows a close-up of a dense area of projecting tension-wood fibers. The severity of the projecting fibers increased from the pith towards the bark. The areas of projecting fibers seemed to be oriented in longitudinal streaks.

Hardwood grading rules do not consider projecting fibers resulting from tension wood. Neverthless, it appears that tension wood should be considered a defect in the grading of green lumber, because of its effect on bowing and crooking as the lumber seasons.

Air-Dried Lumber Measurements: Bowing and cupping were very mild in air-dried lumber, and no difference in severity was noted between tension wood and normal wood.

Tension wood and normal wood both attained an air-dried moisture content of 13 per cent after 9 months of air seasoning. A one per cent moisture gradient was present in the lumber for both types of wood. Mild casehardening was present to an equal degree in both tension wood and normal wood, while light collapse was noticed in some areas of severe tension wood. A summary of results of these measurements is given in Table 1. The data are segregated by log and side of the tree.

Kiln-Dried Lumber Measurements: Bowing in the kiln-dried lumber was significantly greater in boards from the tension-wood side of the tree (Table 2). Boards containing tension wood showed especially severe bowing in localized areas. Dense areas of projecting tension-wood fibers were usually found on the concave side of such severe deviations. Severity of bowing showed an inverse relationship to the distance of the board from the bark. This relationship occurred on both sides of the tree, but was most severe on the tension-wood side. Crooking and cupping showed no significant differences between tension wood and normal wood.

As in air-seasoned lumber, the average, shell, and core moisture contents of the kiln-dried lumber were the same for both tension wood and normal wood. The average moisture content was 8.5 per cent, and there was practically no gradient present in the lumber. The conditioning treatment following kiln drying effectively relieved casehardening in all of the lumber. More collapse was noted in kiln-dried lumber than in air-seasoned lumber, and it was largely associated with the presence of tension wood. Boards containing the pith showed considerable longitudinal splitting. This splitting was evident in the green and air-dried lumber, but became more severe during kiln drying.

A tally of the boards containing tension wood, as determined by projecting fibers, shows them to be almost exclusively limited to the upper side of the tree. Those portions of the lateral boards which extended into the upper side of the tree often displayed projecting tension-wood fibers. The normal-wood boards from the lower side of the tree contained no areas of projecting fibers.

Table 1.—BOWING, CUPPING AND MOISTURE CONTENT OF COTTONWOOD LUMBER AFTER NINE MONTHS OF AIR SEASONING*

Position in tree	Bowing† (%)	Cupping† (%)	Moisture content, per cent		
			Average	Shell	Core
Tension wood (Upper side of lean)					
[illegible] A	0.45	0.63	13.3	12.0	13.7
[illegible] B	0.30	0.57	13.1	12.8	13.4
[illegible] C	0.39	1.62	13.3	12.5	13.6
[illegible] rage	0.38	0.94	13.2	12.4	13.6
Normal wood (Lower side of lean)					
[illegible] A	0.35	0.94	13.2	12.8	13.0
[illegible] B	0.34	1.26	13.0	12.0	13.5
[illegible] C	0.43	1.28	12.8	11.9	13.3
[illegible] rage	0.37	1.16	13.0	12.2	13.3

*The figures for each log are averages of the outside 5 boards.
†Maximum deviation from straightness expressed as a percentage of length or width of the board.

Table 2.—SUMMARY OF THE KILN DRY LUMBER STUDIES*

Position in tree	Bowing† (%)	Crooking† (%)	Cupping† (%)	Moisture content, per cent		
				Average	Shell	Core
Tension wood (Upper side of lean)						
Log A	0.42	0.31	1.03	8.3	8.1	8.3
Log B	0.38	0.40	1.24	8.5	8.3	8.8
Log C	0.35	0.20	.94	8.5	8.0	7.9
Average	0.38	0.30	1.07	8.5	8.1	8.3
Normal wood (Lower side of lean)						
Log A	0.23	0.20	0.96	8.7	8.3	8.1
Log B	0.22	0.34	1.17	8.2	8.2	8.1
Log C	0.21	0.28	1.32	8.5	7.8	8.9
Average	0.22	0.27	1.15	8.5	8.1	8.3

*The figures for each log are averages of the outside 5 boards.
†Maximum deviation from straightness expressed as a percentage of length or width of the board.

Machining

Surface Roughness: Surface roughness was largely based upon the presence of projecting fibers. When boards were milled against the grain, however, chipped and torn grain contributed to the degree of surface roughness. Since an attempt was made to put the boards through the planer so that the cutting action would be with the grain, little difficulty with chipped and torn grain was encountered except where local grain deviation resulted in the cutting action being against the grain. Raised grain was not encountered in any phase of the study.

After the boards were planed, projecting fibers were found to be much more prominent on tension-wood boards than on normal-wood boards (Table 3). This occurred in lumber planed at 6, 12 and 18 per cent moisture contents. The degree of roughness was essentially the same on both the bark and pith sides of the boards. When the grain of tension-wood lumber was straight and ran parallel to the surface, few projecting fibers were noticed after planing, even at the higher moisture contents. Where the grain of tension wood became inclined due to local deviation, however, severe surface roughness was observed.

Severity of projecting fibers and torn grain increased with an increase in moisture content of the lumber at the time of planing, and was more severe when boards were machined against grain deviations. A tension-wood surface planed against the grain at 12 per cent moisture content is shown in Fig. 3. Fig. 4 shows a corresponding board that was planed with the cross grain, and Fig. 5 shows a normal-wood surface planed at 12 per cent moisture content.

Chip marks: Chip marking was most severe at 6 per cent moisture content, and decreased with increased moisture content at the time of machining. There was no significant difference in chip marking between tension wood and normal wood.

Checking: Checking occurred in both tension wood and normal wood, but was much more serious in the tension wood. The checks widened as successive cuts were made at each of the three moisture contents. The enlarging of the checks probably was not due to the effect of increased moisture content, but to the uncovering of spindle-shaped internal checks with each suc-

Table 3.—EFFECT OF TENSION WOOD ON CERTAIN MACHINING AND SEASONING DEFECTS*

Moisture content, per cent	Seasoning checks		Planing				Sawing roughness	
			Roughness		Chipmarks			
	Tension wood	Normal wood	Tension wood	Normal wood	Tension wood	Normal wood	Tension wood	Normal wood
6	1.58	1.08	1.97	1.10	2.55	2.30	1.70	1.00
12	1.50	1.03	2.25	1.13	1.55	1.15	1.60	1.30
18	1.40	1.03	1.85	1.12	1.00	1.00	1.75	1.25
Averages	1.49	1.05	2.02	1.12	1.70	1.48	1.68	1.18

*Lumber surfaces were evaluated according to the following scale: 1. free from defect; 2. light defect; 3. moderate defect; 4. heavy defect. Values in the body of the table are averages of 20 boards each.

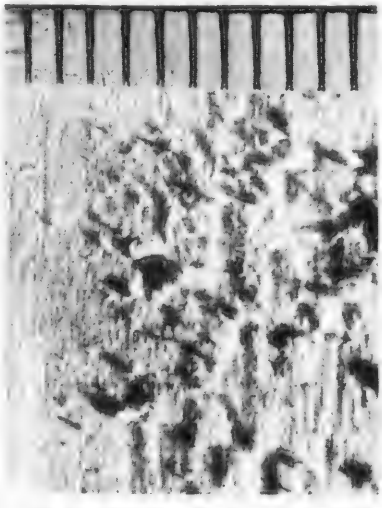

Fig. 3.—Projecting fibers on a cottonwood board containing tension wood and planed against the grain at 12 per cent moisture content. Size is indicated by the millimeter scale.

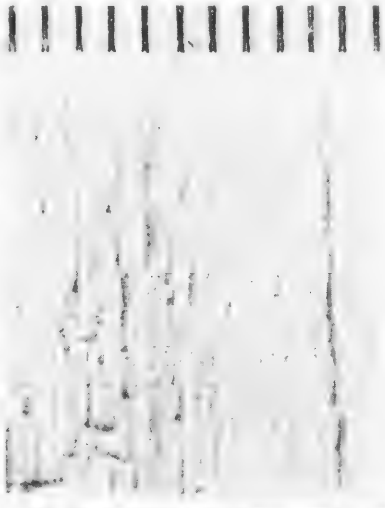

Fig. 4.—Roughness of a cottonwood board containing tension wood and planed with the cross grain at 12 per cent moisture content. Size is indicated by the millimeter scale.

Fig. 5.—Normal cottonwood board planed at 12 per cent moisture content. Size is indicated by the millimeter scale.

Fig. 6—Checking on a cottonwood board containing tension wood and planed at 12 per cent moisture content. Size is indicated by the millimeter scale.

cessive planing of the wood surface. Checking on the surface of a board planed at 12 per cent moisture content may be seed in Fig. 6.

Sawed Edges: Areas of projecting fibers were much more severe along a sawed edge on tension-wood boards than on normal-wood boards. The projecting fiber bundles became coarser on the most severe areas as the moisture content increased. A comparison of saw cuts on tension-wood and normal-wood boards may be seen in Fig. 7. A comparison of tension-wood and normal-wood surfaces on cottonwood lumber machined at the three moisture contents is shown in Table 3.

Conclusions and Recommendations

From these studies it is evident that many of the seasoning and machining difficulties attributed to cottonwood lumber are actually due to the conditions under which the wood was grown. It must be remembered that the 7° lean in the tree used in this study probably represents a border-line tree, and the effects of tension wood would be more severe as the lean increases. Tension wood development at a 7° lean does not appear to affect the air-seasoning and kiln-drying properties with the exception of warping that follows kiln drying. In that case, warping, and particularly local deviation, were more severe in boards that contained tension wood.

The degree of tension wood development in this tree would not seriously affect surfacing the lumber for many uses where smooth surface finishes are not required. For uses that require good surface finishes, however, tension wood should not be used, not only because it gives a somewhat rougher surface when milled with the grain, but because the inevitable local grain deviations will result in severe chipped and torn grain. Tension wood of the degree encountered in this study could be used satisfactorily in hidden parts of furniture if requirements for dimensional stability were not too exacting.

Consideration should be given to marking trees as they are felled in the forest so that the top side of the logs from leaning trees could be later identified by the sawyer. This would enable him to cut boards either from the upper or lower sides of such logs, thus avoiding boards with tension wood on one edge and normal wood on the other, a condition that results in severe warping. The lumber could be more easily segregated for the highest possible use.

The desirability of incorporating some tension-wood identification features into the grading rules should be studied. Veneer log buyers may also find it desirable to consider the lean of a tree in the grading of veneer logs. A knowledge of the effects of tension wood will help a great deal in understanding and correcting some of the problems encountered in the seasoning and machining of cottonwood.

Fig. 7—Comparison of the edges of two cottonwood boards sawed at 12 per cent moisture content. The lower board contains tension wood, while the upper board is normal wood. Size is indicated by the millimeter scale.

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Water Pollution Control in California as Related to Forest Industry Development

PAUL R. BONDERSON

Executive Officer, California State Water Pollution Control Board, Sacramento, Calif.

California has created a State Water Pollution Control Board, with representatives from industry, agriculture, and government, to provide a balance of interests between water users and waste dischargers. The Board does not establish water uses; it only states uses it intends to protect. The activities of this Board are described. With proper control and cooperation, the Board feels the wood-pulp industry could develop its estimated ultimate capacity without creating pollution problems.

WHEN THE CALIFORNIA LEGISLATURE revised the water pollution control law in 1949, it created a decentralized state organization by dividing the State into nine regions. The regional boundaries are based on major watershed areas, and are shown in Fig. 1.

Within each region, there is appointed by the Governor a five-man regional water pollution control board. As shown in Table 1, each board member must be selected from a specified field. It is intended that representation from these five fields will provide an equitable balance in water pollution control activities—activities that must consider both economical waste disposal and preservation of the beneficial uses of water.

A 14-man State Water Pollution Control Board was also created by the 1949 legislation. As shown in Table 1, nine board members are appointed by the Governor from seven designated fields. The remaining five members are state officials representing the agencies listed. And, as in the case of the regional boards, representation on the state board is designed to provide a balance of the interests of the water user with those of the waste discharger. A total of 12 major fields of interest are represented on the State Board.

In their control work, the regional boards are autonomous and have been assigned the primary responsibility for controlling water pollution within their respective regions.

Functions

As regulatory agencies, the regional boards have three principal duties: (1) formulating and adopting long-range plans and policies, (2) setting and enforcing waste discharge regulations, and (3) coordinating the interests of other agencies. The State Board, serving in a coordinating and appellate capacity, is directed to: (1) formulate a state-wide policy for control of water pollution with due regard to the authority of the regional boards, (2) review acts of a regional board where the regional board has failed to take or obtain appropriate action to correct a condition of pollution, (3) administer state-wide programs of research or of financial assistance for water pollution control, and (4) allocate funds for the administrative expenses of the regional boards.

Table 1.—FIELDS REPRESENTED ON WATER POLLUTION CONTROL BOARDS

Regional Board (5 members)	State Board (14 members)
Water supply	Water supply
Irrigated agriculture	Irrigated agriculture
County government	County government
City government	City government
Industrial waste	Industrial waste
	Industrial water use
	Public sewage disposal
	Dept. Agriculture
	Dept. Fish & Game
	Dept. Natural Resources
	Dept. Public Health
	Dept. Water Resources

A regional control board follows four simple steps in controlling pollution. They are:

1. Enunciates beneficial water uses that it intends to protect;
2. Defines water quality criteria to protect beneficial water uses.
3. Prescribes waste discharge requirements;
4. Checks compliance and enforces requirements.

Enunciation of Beneficial Water Uses

In considering the first step, it is necessary to explain what is meant by

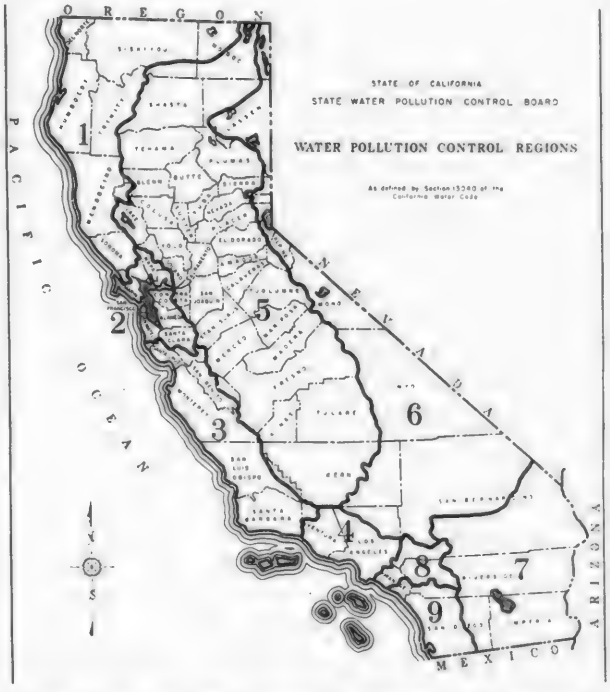

Fig. 1.—The nine water pollution control regions of the state of California Water Pollution Control Board.

[1] Presented at the Spring Meeting of the Northern California Section of the FPRS, held May 2-3, 1957, in Berkeley, California.

The Author: Paul Bonderson holds a degree in civil engineering from the University of California. He has spent six years as a sanitary engineer with the State Department of Public Health and San Francisco Water Department, six years as Executive Officer of the Central Coastal Regional Water Pollution Control Board.

beneficial water uses and why their enunciation becomes so significant in this program. "Pollution" is defined in the California statutes as an impairment of the quality of water by sewage or industrial waste to a degree which adversely and unreasonably affects waters for domestic, industrial, agricultural, navigational, recreational, or other beneficial use. There is no pollution if beneficial uses of water are not *adversely* and *unreasonably* affected. Thus, it is evident that the first problem facing the control board, either in the development of long-range plans and policies or in the prescribing of requirements to regulate individual waste discharges, is that of determining the beneficial water uses to be protected.

The control board does not establish water uses but enunciates water uses which it intends to protect. Prior to making this declaration, the board considers established water uses, planned future uses, and need for economical waste disposal. The board also recognizes that the total interest in any water pollution control program encompasses both economical waste disposal and preservation of the beneficial uses of water. To be certain that all interested parties are heard, the board invites comments on each case, holds informal meetings and discussions, conducts a formal public hearing where necessary, and, lastly, after weighing all the facts, acts upon the matter at a public meeting. In this way, the board serves as arbiter with the duty to hear all interested parties, to evaluate all factors, and, then, to enunciate water uses which it intends to protect.

After the control board enunciates water uses which it intends to protect, it must establish limits on physical, chemical, and bacteriological characteristics (or concentrations) beyond which the quality of the waters are impaired for beneficial uses.

Assume that a community, which is situated on the banks of an inland river, desires to dispose of its sewage and industrial wastes in the river. After considering all factors and interests, the control board determines that it will preserve the river for irrigation, bathing, and fishing. The community will have to provide waste treatment to the extent that the river downstream from the outfall will meet water quality criteria suitable for these uses.

Regulations for control of individual waste discharges are subject to revision from time to time. This does not mean that the discharger is constantly faced with upgrading of requirements on an arbitrary basis. It does mean that his right to the use of waste assimilative capacity in a disposal area or receiving water is subject to proration among other communities and industries which develop after all of the assimilative capacity is used.

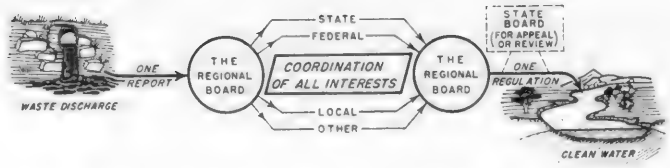

Fig. 2.—One report, together with coordination of all interests, yields one regulation

Although there have been only a few instances where such proration was involved, nevertheless, practically every regulation prescribed by a control board warns the discharger that the requirements are subject to change in order to permit future orderly growth without jeopardizing water quality.

Prescribing Waste Discharge Requirements and Enforcement

The prescribing of discharge regulations is a statutory responsibility—and almost a daily duty—of the regional boards. (The State Board may prescribe requirements, but only in the event that a regional board failed to take or obtain appropriate action to control pollution.) As pictured in Fig. 2, a prospective discharger of sewage or industrial waste is required to file only one report. The board forwards copies of the form and any other pertinent data to all interested and affected parties, thus starting the process of coordination. Where facts are lacking the board asks state or local agencies to make special technical investigations. Before formulating tentative discharge requirements, the board invites comments and recommendations from interested agencies, and informal or formal hearings may be held to develop additional facts. All parties are notified when the board meets to prescribe final discharge requirements. This, the third step, is completed with the waste discharger receiving a single set of regulations.

In the fourth (and last) step, the control board maintains a check on the prescribed requirements to see that they are complied with. If it appears to the board that a waste discharger is violating the requirements, the discharger is first given an opportunity to present his case in administrative hearings. Should the board then decide that a pollution exists or is threatened, correction is ordered. If the waste discharger refuses to comply with the board's orders, the case is turned over to the district attorney for prosecution.

Relationship of Criteria to California Water Plan

The process which the boards follow in controlling pollution has been outlined and described under four basic steps. However, one phase of the process described in this paper may have to be modified in light of the proposed California Water Plan. In discussing the second step of the process, it was pointed out that although the control boards consult with authorities in the field of water quality, the discretionary power and responsibility for establishing water quality criteria rests solely with the water pollution control boards. There will be a major exception to the last statement if the Water Plan, when enacted by the California Legislature, specifies water quality criteria for exported, or other, waters. To understand the reason for this exception, a brief explanation of the Plan is necessary.

California has a critical water problem that results from the fact that the northern one-third of the state is an area of surplus waters whereas the central and southern portions of the State are essentially areas of water deficiency. Three-fourths of the State's water crop falls north of a line drawn through the city of Sacramento, yet three-fourths of the need for water is south of that line. It is simply a matter of poor distribution on the part of nature and is shown vividly in Fig. 3. The solution to the ever-growing problem of water shortages in the southern two-thirds of the state is being evolved in the Water Plan, which will propose exporting water from areas of surplus to areas of deficiency. The widely publicized Feather River Project, shown in part in Fig. 4, is one important feature of the State Water Plan.

The Plan is being developed by the State Department of Water Resources pursuant to broad authorizations of the Legislature. The Department is now engaged in conducting state-wide surveys and studies of water resources and ultimate water requirements. These studies encompass both water quantity and water quality. Upon completion of the proposed water plan, the Department will recommend it to the Legislature. If the plan includes recommendations on water quality, and if the Legislature in adopting a

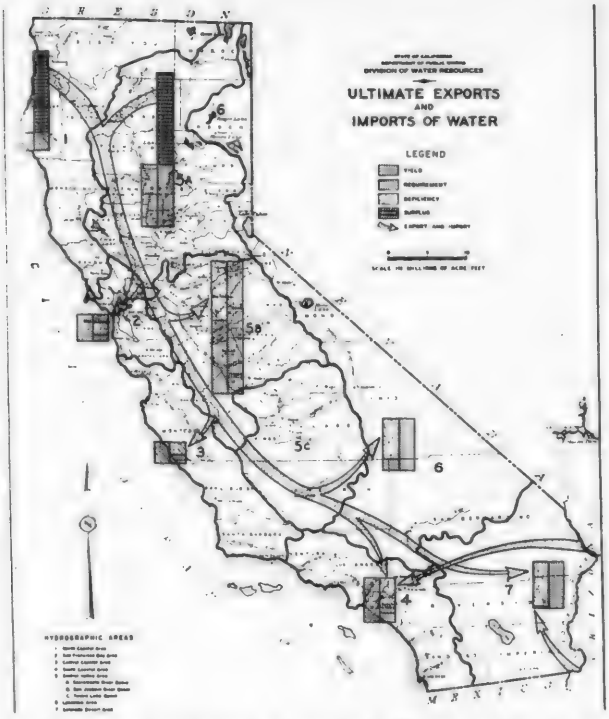

Fig. 3.—Natural distribution of water in California, and how it may ultimately be distributed according to the California Water Plan.

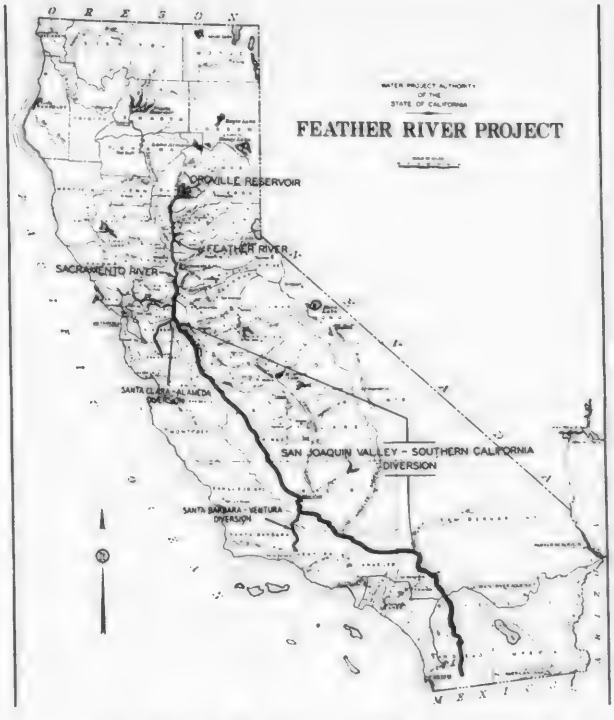

Fig. 4.—The Feather River Project, which will probably be an important feature of the Water Plan.

California Water Plan fixes quality requirements for waters of the state, then these requirements become mandatory. The setting of water quality criteria would no longer be a discretionary responsibility of the water pollution control boards.

Unfounded Fears: The pollution control boards have one serious problem that is difficult to assess, and even more difficult to solve. It is the problem of unfounded fears and mutual distrust surrounding certain cases involving waste disposal projects. This attitude can be extremely harmful to the best interests of the state by preventing objective handling of waste discharge proposals. By creating chaos and confusion, unfounded fears frequently can delay or hamper effective water pollution abatement and can discourage urban or industrial development that would be exceedingly beneficial to the people of California. There was a classic example of this sort of problem, and it is of particular interest to the forest products industry.

About 2½ years ago a cellophane plant proposed to locate in the upper Sacramento Valley. The firm reported what it expected to produce in wastes and, so that it could determine the degree of waste treatment that would be necessary, asked the regional water pollution control board for discharge requirements. Possibly because of unfortunate experiences with discharges from the pulp and paper industry in some other sections of the country, an intense fear developed as to what might happen to the Sacramento River. Feelings and activity were so high that all parties (waste dischargers, water users, the control board, and other public agencies) had difficulty in conducting objective hearings and in confining their deliberations to the California area. It was practically impossible to establish the *fact* that the proposed wasts, even if discharged without treatment, would have caused no significant change in water quality after mixing with the river water, and that complete protection would have been afforded downstream users. Following the hearings on this case, the industry decided not to locate in California. Here was a case where, had it been possible to dispel what appeared to be unfounded fears and some distrust, all interests concerned probably could have encouraged the industry to locate in California.

Not for one moment are the water pollution control authorities suggesting that caution shouldn't be exercised when considering a proposed waste discharge. Quite the contrary, one of the legislative mandates to the California water pollution control boards is to maintain vigilance. But, caution based on facts of a real threat will yield results quite different from caution based on unsupportable fears or based on conditions arising from sad experiences elsewhere.

Cooperative Pulp and Paper Study

Experience from this case demonstrated that, to have intelligent consideration of future cases of proposed pulp mills, data concerning the industry, its wastes, and its resource needs should be available well in advance. As a result, a cooperative study was initiated in 1956 under the sponsorship of the State Water Pollution Control Board. Cooperators in this study included all public agencies concerned with the forest economy of the state, with waste disposal, water resources, and inland fisheries, as well as representatives of the wood-using industries. The participants are as follows:

State and Regional Water Pollution Control Boards.
California Division of Forestry.
University of California School of Forestry.
California Forest and Range Experiment Station, U.S. Forest Service.
National Council for Stream Improvement.
California Departments of Water Resources, Public Health, and Fish and Game.
Representatives from three industrial firms.

The objectives of this study are:

1. To obtain the relationship of water quality and pollution control problems to the pulp and paper mill potentialities in California.

2. In order to make the above determinations, to obtain basic data on fiber resources, mill-site requirements (including water supply), wastes produced after necessary treatment, and waste assimilative capacity of receiving waters.

This study was to have been completed in January, 1957. Unfortunately, the office of the State Board was unable to meet this completion date. The cooperating agencies have completed all sections of the study, however, except the section pertaining to the waste-assimilative capacity of the receiving waters in the areas under study. Since October, 1956, the State Board staff has devoted most of its time to aiding the U.S. Public Health Service administer a sewage treatment plant construction grant program. To compensate for this unexpected increased workload, the Board authorized the retaining of a consulting engineer to complete the water pollution control portion of the report.

Results of Study

It would be premature to present all the results of the study to date. However, certain findings at this stage of the study may be of interest.

The study shows that all the commercial softwoods and several hardwood species found in California are suitable for pulping by presently used commercial processes.

Most of the available pulping processes have application in this state.

From the standpoint of the wood resource alone, there is the potential for a major increase in the production of wood pulp in California. Analysis of the available wood supply indicates that the daily productive capacity of pulp mills in the state could be increased from the present level of 554 tons to a level of approximately 6,000 tons. This is equivalent to twelve 500-ton mills. This estimate is intended as an indication of the size of the pulp industry that could readily be supported by existing wood supplies under foreseeable conditions, and was developed solely for the purpose of water requirements analysis.

For illustrative purposes only, the relative impact that full development of the pulping potential of the state would have on water pollution control will be described. To do this, only one aspect of the problem will be referred to, and that is the organic material contained in waste discharges. This is only one of many pollutants contained in sewage and industrial waste.

For arriving at a common denominator on which to compare the relative effects of various wastes discharged, it is usual to define organic pollution loads in terms of population equivalents. A population equivalent is the average organic waste produced by a single individual per day. The strength or the pollutional effect of the many different types of industrial wastes are converted back to this unit, and can then be used for comparative purposes. For the entire state of California, it has been roughly estimated that the untreated sewage and industrial wastes being handled by community or industrial waste disposal facilities have a population equivalent in excess of 16,000,000. About one-third of these wastes, after necessary treatment, are discharged to land or fresh waters, and the other two-thirds to saline waters.

There are in the state localized water pollution problems, but the over-all picture is good. At the present time, it has been found possible to dispose of these tremendous volumes of sewage and industrial waste without an over-all statewide ill effect. Assuming that the total pulp and paper resources were developed, that is, the entire 6,000 tons per day, and that this development were accomplished through the construction of only Kraft-type facilities, the total untreated waste resulting from such development would have a population equivalent of approximately 2,500,000. This figure is used for discussion purposes only, because the actual value would depend to a considerable extent upon so many factors that it is impossible to use an absolute figure.

Supposing that such development did occur, it is possible to reduce this pollutional load through additional treatment. If the development were confined entirely to sulfite operations, however, the untreated waste resulting would be in the neighborhood of ten times this amount. Fortunately, there doesn't appear to be a likelihood that there will be significant development of the sulfite type in California.

What do these figures indicate? If the untreated pollutional load were in the range of a two-and-a-half million population equivalent, it would appear that the state's water could absorb such a development without ill effect if proper treatment is provided. The converse (in other words, widespread damage) could result to California waters if such a development resulted in wastes being discharged with a 25,000,000 population equivalent.

All life depends upon having a supply of water, and life is just as dependent upon having a means for waste disposal. Development of the Sacramento Valley is also dependent upon a source of water supply and having a means for waste disposal. The Sacramento River provides this dual function of being a source of water supply for the area as well as providing a means for waste disposal. Water pollution control on the Sacramento River is complicated somewhat by the role it will play in the California Water Plan.

The Sacramento River channel is now serving as a conduit for conveying waters for export to central California. Use of the river channel for conveying water for export will take on added significance when the Feather River Project is developed.

The fiber resources section of the report indicates that there is sufficient raw fiber to support pulping operations to the extent of 1,600 tons per day in the upper Sacramento basin. Here again, the total untreated waste resulting from kraft-type operations only would have a population equivalent of 660,000 (or 6,600,000 for the sulfite process). Pollutional loads for the lower Sacramento River would be approximately the same, since the report indicates the fiber resources are nearly identical.

A reasonable interpretation of the significance of these figures is not possible, because even the preliminary studies have not progressed this far. It is safe to say, however, that for the industry to treat and dispose of waste with a population equivalent of 6,600,000 in the upper and also the lower Sacramento basins probably would not be feasible. In situations similar to those that exist in the Sacramento River basin, organic wastes in excess of the 660,000 population equivalent (which would be produced by kraft-type operations) have been disposed of without apparent unreasonable adverse effect on water quality.

It should be re-emphasized that this discussion on organic material pertains to just one of many potential pollutants contained in pulp-mill discharges. Actually, the critical pollutant might be some other constituent of the waste discharge, such as taste- and odor-producing substances or suspended material. Also, local factors are extremely significant when a water pollution situation is under consideration, and the whole control program in California is based on a case-by-case appraisal of each waste discharge.

Conclusions

Until the cooperative study is completed, it is impossible to draw definite conclusions regarding the development of the pulp industry in California as it relates to water pollution. However, it appears that certain findings have emerged from the study to date.

First, there is a wood resource potential that could be utilized to support a pulp industry with an estimated daily capacity of 6,000 tons.

Second, because of low minimum flows during the summer months on most northern California streams, large-scale development of the wood-pulp industry probably will be limited to areas along the Klamath and Sacramento rivers and coastal waters or bays.

Third, indiscriminate and unregulated development of the wood-pulp resources could have an adverse effect on the quality of the waters of the state.

Fourth, with proper planning and by providing the necessary safeguards, there is a good possibility that the wood-pulp industry could expand to the estimated ultimate capacity without creating water pollution problems. Local conditions, however, undoubtedly will be the controlling factor in the actual location of a particular mill. Because of the complexities involved, such local factors cannot be determined in advance. Every proposal for discharging a pulp-mill waste must be decided by the appropriate regional water pollution control board on a case-by-case basis that will take into consideration all the factors involved.

Finally, it is hoped that the report on the pulp resource study will provide a valuable planning aid to both the industry and the regulatory agencies, so that the anticipated expansion of this industry can be achieved without creating water pollution problems.

How to Build Better Frame Homes[1]

C. MILES BURPEE

Executive Director, American Wood Preservers Institute, Chicago, Illinois

Uninformed home buyers must be protected from the costly hazards of decay and termite damage. Early damage which resulted in unexpected repair bills has turned many home owners away from lumber to competitive building materials. An outstanding market opportunity lies cooperatively before the wood-preserving industry and the lumber industry.

THE WOOD-PRESERVING INDUSTRY has two very sound reasons for its reawakened interest in home building. First, it sees a tremendous market opportunity. Second, it sees an urgent need to protect uninformed home buyers, many of whom now have no way of knowing in advance the costly hazards of decay and termite damage. This statement is based on the American Wood Preservers Institute's field investigations of nearly 5,000 existing houses during the last two years.

Right now, the home building industry is under fire from several directions. American Institute of Architects President Leon Chatelain touched off an H-bomb when he said, "Instead of housing Americans as our national welfare demands, we are speedily building bigger and better slums of the future. You may say this is a harsh indictment of our home builders. Perhaps it is. But let us face it honestly; it is also an indictment against ourselves."

Newspaper reports of his speech brought home builders roaring out at the "drawing board dreamers." When the smoke of battle cleared away, they agreed that the best thing for them to do would be to sit down and talk matters over. Some good may come of it.

Home building also is under fire from buyers. AIA President Chatelain put it this way: "The crash program of housing is over; the honeymoon is ended; there is a new, smart, tough and educated buying public already housed and waiting for better houses with better design before they buy again. There is growing selectivity. There is genuine buyer resistance, and with good reason."

The Decline in Home Building

Housing starts have been declining for two years. It now looks as though not more than 900,000 units will be built during 1957, compared with a record high of 1,400,000 in 1950. Among several reasons given for the current decline, are: 1) The supply of new houses has caught up with demand in major cities; 2) High labor costs make it impossible to build lower priced houses; 3) Speculative builders are putting so much costly convenience equipment into houses that they have priced themselves out of the market; 4) Land costs are exorbitant; and 5) Mortgage money is so scarce that only high-income families can buy homes.

There is a striking parallel between what is happening in the automobile

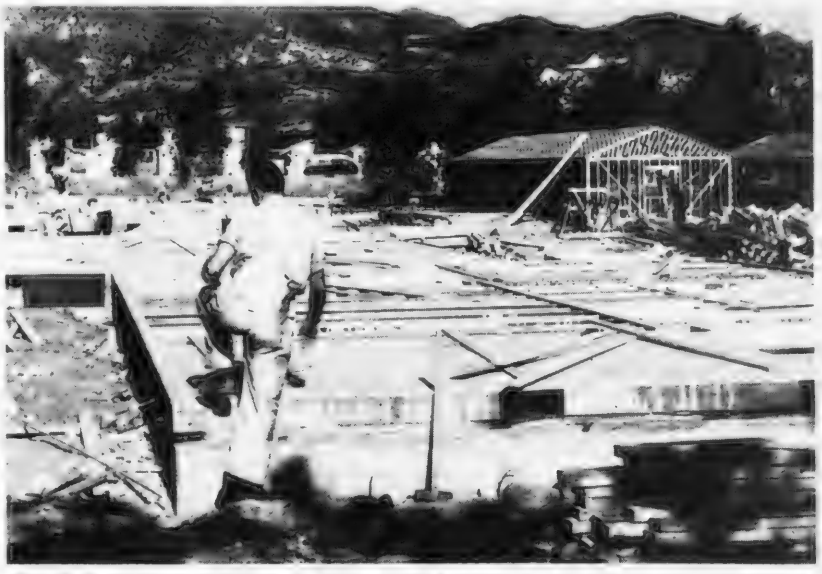

Fig. 1.—Typical installation of pressure-treated lumber for close-to-ground substructure, laid directly on poured concrete foundation of a crawl-space house.

[1] Presented at Session VII, Wood Preservation of the Eleventh National Meeting of the FPRS, held June 23–28, 1957, in Buffalo, New York.

The Author: C. M. Burpee received BS and MS degrees in civil engineering from the University of New Brunswick, Canada. He was an instructor in the Marquette University Engineering School. With the Delaware & Hudson Railroad for 16 years, he served successively as track supervisor, bridge & building master, purchasing engineer and research engineer. He occupied several editorial positions with Railway Age and other papers of the Simmons–Boardman Publishing Corp., and resigned as vice-president to join the AWPI in 1954.

industry and to home building. Both are offering larger, more costly units than ever before. Both involve multi-billion-dollar installment loan obligations. Both have run into difficult problems of declining sales.

Three bedrooms and two baths are considered essential in the most salable houses today, together with a costly array of built-in appliances and other extras. During 1956, FHA surveyed 285 homes in 14 cities, then charged that builders, by exceeding Minimum Property Requirements, tack 39 per cent on to the price of the average home. Extra baths, fireplaces, attached garages, porches, and similar items run up costs very rapidly. If builders stuck to the minima, FHA believes, the average house would cost $7,521, instead of $12,402.

Regardless of causes, the average selling price of houses now is about $16,000, which is more than $3,000 above the 1954 average. As a result, mass buyers of lower priced houses have been forced out of the market. Yet the demand and need for lower priced houses, like lower priced cars, is larger than ever.

Speculative Builders

Obviously, lumber that has been pressure preserved in a closed cylinder costs more than untreated lumber. Furthermore, pressure-treated lumber seldom can be seen in a finished house. That apparently is one reason why more speculative builders don't use more of it. They reason, "It costs more and you can't see it, so why use it?" They quite naturally prefer an "eye-catcher" that costs little and adds to the visible sales appeal of a house. The builder has little concern with a house after it has been sold. But the uninformed owner who has to pay unexpected repair bills because of early decay or termite damage turns against lumber and seeks substitute replacements.

There is plenty of documented evidence to show that this buying reluctance on the part of builders has cost lumber some of its acceptance and markets in the home building field, and has helped bring about the present decline in home consrtuction. One can refer to the continuing series of field investigations conducted during the past two and one-half years by the AWPI. Their purpose was to determine the physical condition of houses built within the past 10 to 15 years in areas of moderate to very heavy decay and termite incidence.

Field Investigations

To date, AWPI representatives have visited subdivisions, developments, and housing projects involving 3,718 dwelling units built of untreated lumber, located in five states, and 1,162 houses built of pressure-preserved lumber, located in 11 states—4,880 units in all. These investigations and other field reports demonstrate that decay and termite problems in homes are found, *in varying degrees,* from New England to the Pacific Northwest, from Florida to California, and in most intermediate areas.

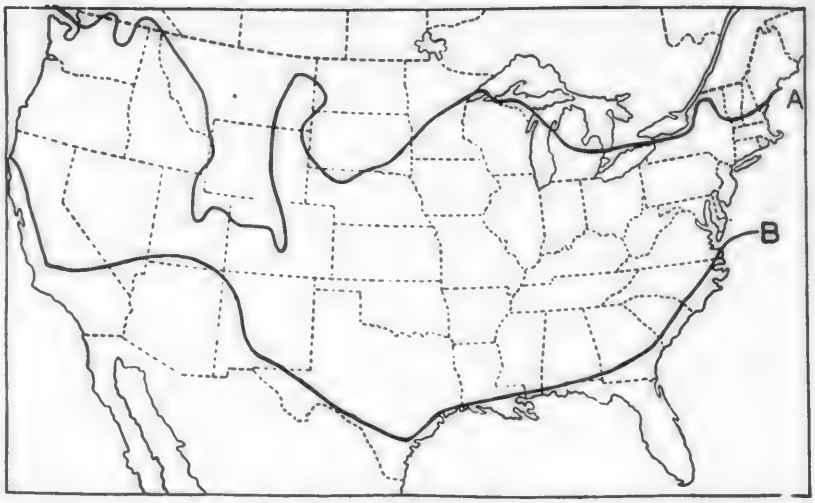

Fig. 2.—A, the northern limit of recorded damage done by subterranean termites in the United States; B, the northern limit of damage done by dry-wood or nonsubterranean termites. The subterranean termites are extremely adaptable to their environment. Areas of heaviest incidence include California, eastern Texas and the states bordering on the Gulf of Mexico, Georgia, South Carolina, and eastern North Carolina.

In 1955, AWPI field investigators made intensive studies of about 2,000 homes, of which about 1,200, built in four states, were of untreated wood; and 759 homes in 11 states were built with varying framework items of pressure-treated structural lumber. Building-permit repair records and personal examinations determined the extent of the damage.

One study in the San Francisco area involved about 525 homes in three subdivisions. The houses were built of untreated lumber, from 1942 to 1948. Repairs and replacements due to decay and termite damage averaged $200 per house on 24 dwellings in one development; $348 each on 34 units in another; and $484 on each of 31 houses, respectively.

A Los Angeles city ordinance, in effect from 1934 to 1949, required that all joists and wood members below the joists be pressure treated. During that period, 200,185 single-family dwellings were erected. They were crawl-space type, with less than 24-inch clearance, and contained an average of 1,200 f.b.m. of pressure-treated lumber. An interesting sidelight is that the added cost of about $30 a unit did not in any way retard the building of houses.

A comprehensive investigation of these Los Angeles houses in 1955 showed that less than one per cent had been attacked by subterranean termites or decay. Houses built of untreated lumber outside the city limits during the same period showed an average subterranean termite infestation of 78 per cent, 30 per cent for decay, and average repair bills of more than $300 per damaged house.

Conditions Along Gulf Coast and in Florida

AWPI's surveys in Texas, Louisiana, and Florida, during 1956–7, further proved the need for pressure-treated lumber in houses. A regional FHA Minimum Property Requirement, in effect for about 15 years in the Houston area, required a layer of asphalt-impregnated building paper to be laid over a continuous foundation wall, or the perimeter of a slab-on-ground floor. Its theoretical purpose was to serve as a vapor barrier and prevent decay of untreated wood sills laid over the paper. AWPI investigations were made to determine the conditions of sills in houses built in the area during the past 10 to 12 years.

Representatives examined 352 houses, out of 822, built in four Houston, Texas, subdivisions since 1946. More than 90 per cent had decayed sills, and more than 52 per cent were or had been infested with termites. Several houses in the Houston area actually were in such poor condition that owners had abandoned them and thrown them back on mortgage lenders and FHA.

In Florida, AWPI investigators visited the Greater Miami area, Tampa, Gainesville, and Jacksonville. They covered 16 developments in which 2,062 houses had been built since 1946, and selected houses at random

Fig. 3.—This 28-foot wall in a Florida house dropped 4 inches when the 4 by 8 inch untreated wood sill failed because of intensive termite attack.

where owners were seen in their yards and were available for interviews.

Results revealed that many uninformed owners who bought homes in good faith, later suffered serious financial losses because of decay and termite damage. Total damage of this nature within the state is conservatively estimated at $15 million a year. Whenever possible, home owners seek lumber substitutes when forced to make repairs and replacements. Untreated lumber is losing both its reputation and its markets. One Florida home owner summed it up when he said, "Termites are about to eat this place up. About all we'll have left when the mortgage is paid off will be the lot." And that is not a rare case.

AWPI found that the entire state of Florida is an area of very heavy incidence of decay and insect attack. Termites are so plentiful, so active, and so destructive, that approximately 2,500 persons are employed in their extermination. Apparently three species of subterranean termites cause most of the damage, although drywood termites occur all over the state and are most active in the St. Petersburg–Tampa area and from there on south along the Gulf Coast, from Orlando south in Central Florida and from West Palm Beach south on the East Coast.

Jacksonville Project 90 per cent Infested

Jacksonville now has more than 95,000 dwellings. Interviewers inspected representative houses in five subdivisions made up of 622 dwellings. As in earlier surveys at Houston and New Orleans, they found houses with collapsed sills. Repairs involve more than replacing damaged lumber. Collapsed sills pull the entire house out of plumb, and repair costs often include interior partitions, floors, walls, and redecorating.

For example, interviewers visited a 200-house, slab-on-ground project, built under FHA Minimum Property Requirements in 1950. This project appeared to be more than 90 per cent infested by subterranean termites. Inside damage was evident in baseboards and cracked ceilings. Outside were decayed porch posts, screen frames, fascia boards, and rafters.

By way of contrast, interviewers visited a nearby 12-house project of the crawl-space type built in 1947 with pressure-treated sills. These homes were sound and in good condition. In one house, termites had built tubes over the treated lumber to reach untreated material and slight damage was found in a door frame and posts of the carport.

Investigators covered seven additions in the Greater Miami area. The city itself has about 200,000 dwelling units. As in previous interviews, owners here were reluctant to talk about decay or termites in their houses unless damage was severe. Those with slight damage apparently had resale values of their houses in mind.

Owner dissatisfaction and high turnover were revealed in visits to various developments here. Typical of the condition of several frame homes of the crawl-space type built in 1947 was one where the owner had just obtained an estimate of $1,568 for replacing sills and re-siding.

Five "For Sale" signs showed rapid turnover in a group of 46 Miami area houses built in 1948, sold for $7,500 each. Owners say they have replaced sills, siding, porch posts, fascia boards, window casings, and sash.

Decay was rampant in a 200-house addition built seven to 10 years ago in southwest Miami. Two owners were quite critical of lumber.

Tampa Doubly Infested

The city of Tampa has about 62,000 dwellings, less 250 that the city's building inspector condemned recently as unsafe for human habitation because of termite damage. Residents of Tampa have to contend with both subterranean and drywood termites, plus very heavy decay damage. Decayed roofs and porches were frequently noted. During one interview, an investigator urged a housewife to have her porch roof repaired "before it falls down on your children."

In a 150-house project, built six years ago (sales price $7,000 to $9,000), use of lumber was limited to roofs, screen frames, and porches. Many original wood doors and frames have been replaced with metal.

Florida building commissioners in several cities revealed the extent to which CBS (concrete block-stucco) construction has displaced wood. "Frame construction is illegal here under the present building code," said one. "It was laxness of the code, or just plain false economy, that spelled the death knell of untreated lumber. It all goes back to bad policing of the construction industry, and lumber became the 'fall guy.' We take a dim view of untreated lumber in contact with CBS."

Another commissioner said, "To the best of my knowledge, not more than 12 permits have been issued for all-wood frame residences in the past year."

A third reports that, "Not more than 10 per cent of the new houses are frame, and most of those are by builders of 'shell-type' homes." He personally favors frame houses, primarily from an appearance and comfort standpoint.

Lumber's most enthusiastic boosters should recognize that putting a piece of untreated wood on or near the ground in Florida and parts of California, two of the nation's most active home building markets, is about like exposing a sheet of carbon steel to a salt water spray. Neither will last very long. But there is no reason to discard any good material merely because it needs protection.

Decay and termite damage to homes is unnecessary and avoidable. Hundreds of homes up to 41 years of age have remained free from these ravages by reason of the judicious use of pressure-treated structural lumber. Based on these findings and 34 years of experience in its development work, the AWPI has prepared practical rec-

ommendations for preventing structural deterioration. Furthermore, the AWPI is urging FHA to adopt and enforce practical Minimum Property Standards that will insure the building of homes that will outlive the mortgage.

Decay is More Prevalent

Annual losses from the decay of all untreated wood in service throughout the United States amount to some $300 million, whereas the annual feed bill for termites and other wood-destroying insects runs from $150 to $200 million, according to the U. S. Forest Products Laboratory.

Decay—the greater and more insidious destroyer of the two—quickly attacks untreated lumber in damp or moist environment. Regional differences in the rate of decay are closely related to the moisture content of untreated wood. Moisture condensation, for example, is very prevalent in the northern half of the country and also accounts for considerable decay in Florida. Rain seepage and soil moisture are more pronounced in South Central and Southeastern areas. The only possible exceptions to decay hazards are the very arid sections, especially in the Southwest.

Why Untreated Lumber Rots

Much of the lumber used by our forefathers to build their homes came from the heartwood of virgin timber, which was protected by concentrations of naturally resistant resins or oils. That is one of the reasons why those homes lasted for generations. Today's lumber is cut mostly from fast-growing species. Such lumber usually contains a large proportion of sapwood, which has relatively little resistance to decay. When reinforced by standard pressure-preservative treatment, however, these species are converted into excellent long-lasting lumber that is impervious to both decay and termites.

Although considerable misplaced confidence has led to the use of so-called naturally durable woods, general availability of such species is strictly limited. It is true that the heartwood of some species of wood is resistant to decay, but no wood in its natural untreated state is as effective against decay as properly treated wood. Specifications that require a percentage of heartwood in lumber generally are ineffective, because the surrounding sapwood deteriorates and leaves only a portion of the stick intact. Moreover, there is a considerable variation in the durability of wood from the same species and even from the same tree. Durable pieces generally can not be detected by visual inspection. None of our native wood species is immune to termite attack except when preservatively treated.

Shields Will Not Stop Termites

Although good design and good construction are important, widespread decay and termite damage clearly prove the inadequacy of these factors alone in homes of modern design. Woe betide the unsuspecting home owner who puts his trust in termite shields, because they provide little or no permanent protection, even against subterranean species. Furthermore, they are useless in preventing inroads of drywood termites and decay.

Perhaps 95 per cent of all termite shields installed to date have been ineffective and the money spent for them has been wasted, is the opinion of Dr. R. J. Kowal, entomologist, U. S. Department of Agriculture. Such opinions are common among many authorities. Moreover, 14 out of 15 district officers of the FHA recently condemned the use of shields. Georgia's chief architect went so far as to estimate that at least 85 percent of the FHA houses built in that state with termite shields are now infested with termites.

Soil-poisoning methods and chemicals used as termite barriers are widely diversified and depend upon the various interests of the operator. Experience indicates that the effectiveness of such treatments must be considered a temporary expediency subject to guarantees usually limited to five years or less. No amount of soil poisoning will stop rot or infestations of drywood termites.

Low-Cost Permanent Protection

How then can decay- and termite-proof homes be built at modest cost? Complete protection in areas of heavy incidence of decay and termite attack, especially in areas where drywood termites abound, can be achieved only by preservative treatment of all the lumber in the house. For areas of light to moderate attack by decay and subterranean termites, AWPI surveys and 34 years of experience have led to the development of specific building recommendations for the use of limited quantities of treated lumber that will provide reasonable protection.

A frame, brick-veneer house was built in Jacksonville, Florida, in 1956. It cost $462 to treat all the framing lumber from foundation to peak, including the roof boards. This cost amounted to only 2.1 per cent of the $22,000 valuation, or 2.4¢ per sq. ft. of floor area. This home has a floor area of 1,918 sq. ft.

Pressure-treated sills, blocks, posts, girders, joists and subfloor will add only about 10¢ per sq. ft., or $118, to the cost of a typical 30-ft. by 40-ft. home, in a typical community.

When the cost of pressure-treated lumber is correctly analyzed as insurance against deterioration and expensive repairs, it becomes almost an incredible bargain. Fire insurance is mandatory on all mortgaged homes. The total cost of fire insurance on a typical house for a 30-year period would amount to $883 in contrast to $288 cost for complete treatment or $118 cost for partial treatment. Pressure-treated lumber will not deteriorate and will outlast any 30-year mortgage by a great many years.

No rational home-owner goes without fire insurance. But insurance against the expense and inconvenience of damage from termites and decay, which can be had through treated lumber at one-sixth the cost of fire insurance, has been largely overlooked.

If every prospective home owner, the mortgage loan officers of every bank, insurance company, and savings and loan association, knew of the long life and genuine economy of pressure-preserved lumber, properly used in homes, there would be no sales problem. The wood-preserving industry's biggest untapped market would open up and grow like the first crops on rich, newly irrigated land.

The attitude of the speculative builders has already been explained. It is understandable, but regrettable. AWPI believes that some lumbermen and their trade associations should take a new look at wood preservers as logical, natural allies who are helping lumber retain its place and even regain some of its lost markets in the home building field. This is a delicate subject, but the sooner lumbermen and wood preservers begin working together to make houses last longer without early costly repairs, the sooner they will experience a general increase in per capita consumption and sale of lumber.

One sure way for the home building industry to stage a comeback is to put more sound, inherent, permanent values into basic structures, even though these values do not appear on the surface.

Prospective home owners would gain increased confidence in the integrity of a contractor-builder who can demonstrate that he is putting lasting, inherent values into his houses. That builder would gain a competitve advantage that would help him in the present declining market. Owners would gladly use more lumber in their houses, rather than seek ways to avoid

Fig. 4.—Typical view of crawl space under a Ben Tillman home, Charleston, S. C., 14 years after it was built. All joists and girders were pressure treated.

its use. When that is done, the lumber industry, working with wood preservers, can win back some of the housing business that has gone to competitive materials.

The need, opportunities, and consequences of inaction have been described by Arthur M. Weimer, economist for the United States Savings & Loan League. In a San Francisco management conference on May 20th, 1957, he expressed the opinion that most buyers are not certain they are getting adequate value for the dollars they spend for new houses. He said: "Unless the home building industry can give the home buyer greater value per dollar of expenditure, he will choose to improve his living standards in other directions than in the housing field." . . . I say that pressure-preserved lumber in houses gives the home buyer greater value per dollar of expenditure.

Discussion

E. George Stern (Virginia Polytechnic Institute): Can you provide us with figures on the availability of treated lumber in lumber yards? I have in mind the local building materials dealers from which the average builder purchases his lumber and would purchase treated lumber if available.

While we recognize the benefit derived from the use of treated lumber, it will not be used by the small builder so long as it is not locally available. It appears that this is a field in which your Institute could accomplish a great deal: Wide-spread local distribution of standard-size treated lumber.

Mr. Burpee: Wherever local ordinances or building code requirements provide for the use of retreated building lumber, large stocks are maintained by dealers and lumber yards. This is particularly true in Southern California and cities and towns in Southern states. The treating industry is moving more into the field of pressure-treated building lumber and the products are being made more generally available as times goes on. Nevertheless, the fact remains that in some areas it is still difficult to procure standard sizes out of retail dealers' stocks.

Dr. Stern: Isn't it true that pressure-treated lumber has considerably smaller nailholding power than non-treated lumber? In light of this, wouldn't it be advisable to use more effective properly threaded nails and staples for fastening to treated lumber than the customarily used plain-shank or barbed nails? Many dealers sell threaded fence staples to purchasers of pressure-treated fence posts because of the advantages offered by these staples in fastening the fence wire to the post. Similarly, I believe that properly threaded framing nails should be offered by the lumber dealer to the purchaser of pressure-treated lumber to make it possible for the builder to derive the maximum benefits from the use of such lumber.

By selecting properly helically threaded nails, the builder can face-nail the treated sill to the end of the stud, and thus eliminate the relatively cumbersome and less effective toe-nailing required when plain-shank nails are used. He can use a smaller number of smaller size, threaded nails, and erect a better structure at an actual saving in field labor.

Mr. Burpee: I am not in complete agreement with your first statement. With respect to nail-holding ability, we know of treated fences 30 years old that are still in good condition and the staples have held satisfactorily.

T. E. Workema (Dow Chemical Co.): Have you varied your recommendations to FHA for different geographic locations?

Mr. Burpee: Yes.

B. C. Williams (Norfolk Naval Shipyard): Do you have any recommendations for dipping or soaking? Also, I know that you work with building code authorities—have you made any recommendations to the building trade unions?

Mr. Burpee: We have not tried to work with the trade unions. Insofar as dipping and soaking are concerned, all investigations convince us that pressure treatment is the method to use for structural lumber.

Mr. Williams: In other words, you have made no investigation of methods which the small builder might use, but do you have any findings with regard to dip or soak treatment?

Mr. Burpee: There is no difficulty in procuring pressure-treated material in areas of heavy infestation.

Roy M. Carter (N. C. State College): What are the results of AWPI recommendations to FHA and VA? Will termites be deterred by properly treated lumber?

Mr. Burpee: Field inspections made by the AWPI of 759 houses, built with varying amounts of pressure-treated lumber in 11 different states revealed that in only one instance was there any evidence that termites had built tunnels over pressure-treated wood to reach untreated lumber. In the light of these investigations and inspections we are convinced that pressure-treated lumber has proved its value as positive protection against both termites and decay.

Arne K. Kemp (Austin State College): It is common knowledge that there are other known methods of treating which will do an effective job for most home construction purposes. Are you recommending to FHA that only pressure-treated lumber be used in construction, or are you recommending that only lumber that is properly treated, with the necessary penetration, retention, and distribution, should be used for home construction?

Mr. Burpee: The subject of my paper deals primarily with the need for treated framework or dimension lumber. Research investigations by the Forest Products Laboratory at Madison, Wisconsin, clearly indicate the superiority of standard pressure treatment with standard preservatives for these purposes. The results were published in FPL Report No. 2043, "Study of the Preservative Treatment of Lumber".

Economic Aspects of a Particle Board Operation[1]

DONALD R. SEIP
Donald R. Seip Co., New York, N. Y.

The seven primary economics aspects of a particle board operation are developed. The author believes the term, "medium-density" board is more inclusive and appropriate for the field. Medium-density board is shown to be in a favorable economic position relative to hardboard and plywood.

THE SUBJECT, "ECONOMIC ASPECTS of a Particle Board Operation" is somewhat difficult, because the industry is relatively new in this country and much experience must be gained in manufacture, application and marketing before the economic aspects of the industry can be truly evaluated.

In this paper, the product will be called medium–density board rather than particle board because, in the author's opinion, the term particle board applies only to a particular type of medium-density board. As yet, there have been no clear-cut definitions or standards established by the industry for the various types of medium-density boards being produced or in development, and no attempt will be made to classify and define each type of medium-density board or process, because the economics must deal with the industry as a whole. But for the purpose of this paper, the medium-density boards will be classified as follows:

1. Planer shavings board, which is prepared from either green or dry planer-mill shavings;
2. Particle board, which is made entirely from small chips or particles, and may also be defined as chip board;
3. Combined particle and shavings board, which is made of small particles or chips and surfaced on one or both faces with flakes or shavings;
4. Prepared shavings board, which is a board made entirely from prepared shavings.

Raw Material Supply

The first important economic aspect to consider is the basic concept of raw material supply.

Problems to be considered include: 1) The form of the raw materials and type of medium-density board they will produce; 2) Period of availability; 3) Current outright ownership versus cutting rights, purchase on the open market, lease arrangements or possible future acquisition; 4) Industry segments with effect on raw materials that is, whether the raw material is a by-product of another industry which in turn is subject to higher or lower production; and 5) Whether the raw materials should be diverted to some other product such as paper or hardboard.

Quality to be Produced

Regardless of the category in which the board falls, the quality of product the raw materials will produce must be predetermined; one must know whether or not the product will be competitive with other items at the market place or at the source of raw materials. Certainly there is no economic advantage in producing a board that does not have the properties to conform to the market requirements. A medium-density board must have: good stability, low water absorption, low expansion and contraction, superior surfaces, high bending strength in both directions, light weight, good screw- and nail-holding properties, good glue bonding properties, and good machinability. It cannot be deficient in any of these properties.

To produce a medium-density board with all these properties is not an easy task. The wood or wood residues must be clean, bark and rot free, and of all one species. If mixed species are used, the ratio must be constant and the particles, flakes, or shavings must be prepared with the least amount of fiber damage.

Actually, making medium-density board is no different than making paper, insulation board, or hardboard. Suitable raw materials in each case must be carefully selected and then processed through the various steps of wood treatment, fiber preparation, refining, screening, blending, chemical addition, forming, drying, and finishing. None of these steps can be omitted in making medium-density board anymore than they can be omitted in making paper, hardboard, and insulating board, or cost and profit will be adversely affected.

Fig. 1.—The RoddisCraft particle board plant at Arcata, California. The plant was designed and built by the Donald R. Seip Co.

[1] Presented at the Spring Meeting of the Northern California Section, FPRS, held in Berkeley, California, May 2-3, 1957.

The Author: Donald Seip is president of the Donald R. Seip Co., Industrial Consultants in various fields, and Industrial Plant Builders. Before forming his own company, Seip was with Johns–Manville for several years, and managed a number of operations.

Initial Cost

The third economic aspect is the cost of entry into the field. A medium-density board plant that will produce board with all the necessary properties will require a basic investment for plant alone of somewhere near $3,500,000 (in the author's opinion). This is for a sound economic unit, not for captive plants. Should a 250-ton unit become the economic level, an investment of $5,500,000 or $6,000,000 should be considered as the minimum for plant alone. One must also consider the probable immediate and long-term effect on profit margin by the construction of competitive plants.

There is no easy way to get into the medium-density board business anymore than it is easy to get into paper, insulation board, or hardboard. A peckerwood sawmill might show a very attractive return on investment for six months but it is so inexpensive and so easy to get into that one would hardly classify it as having long-term value or attraction.

On the other hand, a $12,000,000 insulation-board plant or $25,000,000 paper mill, if economically attractive, is something that cannot be duplicated by just anyone or at just any time. This will also be true in the medium-density board field as time goes on and production is increased.

Market Price and Profit Potential

The fourth economic aspect is the probable market price level and profit potential, as indicated by established and currently widely used competitive products. Thus, in establishing an anticipated market price for a medium-density board, one must consider the probable market price for: 1) competitive utility-grade plywood such as Douglas-fir plywood; 2) competitive lumber; 3) competitive hardwood plywood; 4) competitive components of hardwood plywood where the medium-density board will suffice as a core material rather than as an end product in itself; and 5) directly competitive medium-density boards. One board may require a crossbanding on both sides at 6 cents a square foot to make it the equivalent of another board. Then the board of a quality that eliminates crossbanding can evaluate the position of the one requiring it, and can safely anticipate a higher market price of 5 to 6 cents per square foot.

Studies of Douglas-fir plywood indicate that, with a fair long-term value for peelable timber and known methods of fabrication, a price of more than 20 cents per square foot is necessary to show a fair return on investment for a product of sound 2 sides, solid—jointed core in ¾ thickness.

Inasmuch as ¾ medium-density board can compete directly with ¾ Douglas-fir plywood for the many end uses in which plywood's extra strength is not needed, then it is safe to assume that, at that point, a good medium-density board can demand a price of 20 cents a foot and be competitive.

Because a good medium-density board has no patches, no core joints, no knot holes, no grain raise in the face, and no warp or twist, it should compete with a product that tends to have all these shortcomings and still has an economic value of more than 20 cents a foot.

This is not to say that Douglas-fir plywood as an industry is selling at a price of more than 20 cents, because it isn't. As an industry, it seems to favor a course of loss or no return, which in turn may affect the medium-density board market adversely in some cases.

But anyone studying the economic aspects of any product would be well advised to spend some time determining the extent to which the marketing economics of Douglas-fir plywood can be ignored. Not only do users abhor the price gyrations of Douglas-fir plywood, but they abhor the secondary effects of variable quality that follows such price gyrations. There is always someone who tries to compensate for price inadequacy with lowered quality.

There has been just enough of that in plywood, both softwood and hardwood, to cause many users to say "welcome" to a product that can safely avoid such quality gyrations and price gyrations.

A medium-density board plant has little or no temptation to sacrifice quality, because a properly conceived and designed plant can be operated at about the same cost and productive rate on good quality as it can on poor quality. In the author's opinion, a good medium-density board will be competitive in the price-range mentioned, and the plant will show a good return.

Foreign Competition

The fifth economic aspect is foreign competition. To judge the importance of such a consideration one has only to recognize that, in the last 6 years, imported hardwood plywood has increased from nothing to 50 per cent of the total market in the United States.

As to medium-density board, it appears that the principal components of cost are: 1) raw wood, 2) resin, 3) labor, 4) utilities, and 5) depreciation, insurance, and taxes.

There is nothing to indicate that good board can be made in a foreign country and shipped into the United States at a cost appreciably lower than our domestic cost. In fact, board of one quality—and from one process—made in such widely separated points as Germany, Japan, and the United States tends to cost within a $1.00 or $2.00 per thousand feet of the same amount to make in all three countries.

Individual cost components may vary, but the total seems to run about the same. For example, German labor costs are about ¼ of ours, but their wood costs are several times higher. Japanese labor costs are very low, but their wood costs, resin costs, and shipping costs are such that their total cost F.O.B. Japan is almost identical with U.S. costs F.O.B. mill for the same quality product.

Fig. 2.—Part of the raw material supply for the operation of the Arcata particle board plant.

In other words, basic costs do not vary so radically in medium-density board as in many competitive products. There seems to be no foreseeable change for sometime to come in this situation.

Labor Costs

The sixth economic aspect is one that deals with current vs. probable long-term competitive position with respect to labor costs.

For example, it takes so many man hours to produce Douglas-fir plywood or hardwood plywood or lumber.

Ninety to 100 square feet per man hour ⅜ basis is considered appropriate for a good grade of Douglas-fir plywood, whereas a figure as low as 10 feet per man hour surface measure basis, at a comparable level of self sufficiency, may be indicated for hardwood plywood.

Medium-density board can be computed at about 350 square feet per man hour ⅜ basis, at present, which gives an indication of its relative immunity to labor costs in judging its future competitive position in relation to fir plywood and hardwood plywood.

Assuming the above figures on fir plywood, hardwood plywood, and medium-density board to be accurate as of any given time, then increases in labor costs will be only about 1/3 as serious in medium-density board as in fir plywood and only about 1/35 as serious as in hardwood plywood.

Marketing

The seventh economic aspect is developing a marketing program. This problem must be considered not only from the standpoint of immediate dollar costs but also as to long range complexities.

From an immediate viewpoint, for example, if one were starting a Douglas-fir plywood plant, he would not necessarily be too concerned with marketing because there is an entire fraternity of so called wholesalers who will not only take over the sales but will probably advance money to the mill for the privilege of handling its sales.

In the medium-density board field there is no such fraternity of wholesalers, and it is probably a real blessing for the medium-density board industry that it is not saddled with this handicap at this stage.

Medium-density board can not be properly marketed except with a skilled salesforce properly directed so as to take advantage of its many peculiar qualities. It should not be brought to market in the way lumber and plywood are brought to market.

Proper solution of this problem may be the most important one to be faced in establishing a medium-density board operation if one is to avoid the situation in which lumber and plywood find themselves.

In conclusion the economic aspects to be considered include: (a) basic concept of raw material supply, (b) quality of board to be produced from these materials, (c) cost of entry into the field, (d) probable market price level and profit potential, (e) foreign competition, (f) long-term labor cost outlook, and (g) developing a marketing program.

Methods of Attaining Greater Logging Safety[1]

E. H. REEVES

General Manager, Lumbermen's Safety Association, Toronto, Ontario

Accidents indirectly cost an additional $4 for each dollar spent for medical aid and compensation. The over-all accident-control program developed by the LSA includes cartoons, movies, and posters. The approach is different for management, supervisors, and employees.

AN ACCIDENT can best be defined as an unplanned event caused by an unsafe act or an unsafe condition.

Since all elements that make up a production schedule are planned events, it is apparent that an unplanned event (an accident) will interfere with that schedule. The degree of effect is controlled by the nature and the time and place of the accident. To illustrate, an accident that occurs during the cutting and skidding operation generally has less effect on production than one that occurs during the peak of the haul. An accident during the haul could conceivably create chaos and strangle production for an appreciable period of time.

Although these facts are elementary, they lead into that most interesting phase of production, namely *costs*.

Accidents cost money, as is generally admitted, but not quite so readily appreciated is the amount of cost involved in accidents.

The 4-to-1 formula established by Mr. W. Heinrich applies to the logging industry as well as to any other industry. A recent study of accidents on the logging operations of a large pulp and paper company in Northern Ontario indicated that injury-producing accidents had an indirect cost of $5.35 for each dollar expended on medical aid and compensation. The cost of non-injury-producing accidents, which, according to Heinrich, exceed injury-producing accidents by the ratio of 10-to-1, has not been established, but we can assume that it approximates the indirect costs of injury-type accidents.

Generally speaking, the above cost formulae have been accepted by safety engineers and are being accepted by management.

Since cost control is a vital item in production, and since accidents interrupt production and increase costs, it is necessary to make accident control an important function of management. That is easier said than done.

Logging, perhaps more than most industries, is hallowed by a colorful, in fact robust, tradition. The main theme of that tradition is toughness, which, on closer examination, is merely bravado. This attitude, which extends from management to the employees, is as tough to break through as the sound barrier. It is the state of mind that boasts of logging as a tough, dangerous business, considers accidents inevitable, and accepts a phenomenal accident frequency as part of the logging picture.

It is a state of mind that is difficult to change, and the approach has

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The Author: E. H. Reeves holds a BS in forestry from the University of Toronto. He spent 18 years in various phases of the wood industry, chiefly administrative work in logging operations, until he joined the Lumbermen's Safety Assoc. in 1952.

Talkwell knows the rules, and he makes everyone toe the mark
What's going on here? You guys know TALKIN' IN THE COOKERY is agin the rules. If ya don't like it you know just what ya can do!
Who ME? Tell my men to wear HARD HATS - I wouldn't DARE they'd all quit on me...
BUT When it comes to making his men wear SAFETY EQUIPMENT it's a different story.
LSA

Fig. 1.—Many companies in Ontario observe strict compliance with the ridiculous rule of no talking at meal time. It is used in this cartoon to ridicule mildly management that retains tradition without reason, but that opposes instituting orders that will prevent injury.

If you'd get off it and give us a hand, maybe we could get the Job done!
EFFORT TO REDUCE ASSESSMENT
60
ANNUAL SAFETY MEETING
2690

Fig. 2.—Many of the cartoons rib management on their lethargy in actively organized accident prevention. Those who did not attend the LSA Annual Meeting were likened to an oaf.

to be well-planned and varied as to the class of individual with whom we are dealing. The approach to management should be entirely different from the approach to supervision, which again is different from the approach used with employees.

That brings to mind a story that may illustrate the point. A newly inducted private was standing on the parade grounds when an officer dropped a handkerchief as he passed. The recruit raucously called out, "Hey bud! You dropped your handkerchief." The passing officer picked up the handkerchief and continued on his way. A chum of the recruit arrived on the scene and told him that the officer was General Montgomery. The recruit was mortified and rushed to overtake the General and apologize. Montgomery calmed the lad and then admonished, "Be sure that you never address a 2nd Lieutenant in that manner."

The Lumbermen's Safety Association work on the safe premise that the bigger the man, the less chance of his being offended at a direct and sharp approach, even if that approach is, within reasonable limits, critical, sarcastic, insinuating, or any other style of reprobation. Such an approach is to management as a whole and not to any one individual.

One way of getting this message delivered is by means of cartoons, which are published in the LSA monthly paper directed to management. A few samples will be presented with a brief summary of the accompanying editorial.

These cartoons show that we do not hesitate to brand indifferent management as lazy.

There has been no resentment shown toward these cartoons. Any protesting individual would, of course, be branding himself. These and similar cartoons have had excellent results. No one wanted to be considered as a subject in such a picture.

LSA also forcibly brings to management's attention, by direct mailing of colorful pamphlets, some of the spectacular results (cost-wise) of recent accidents. For example, last year five deaths resulted from head injuries, all of which could have been prevented by hard hats. The cost of these five fatalities amounted to $75,000. The pamphlet treats each case separately, and then sums up by stating that five unused hard hats cost the industry $15,000 each.

Of course, personal contact is maintained with senior management by means of group and private meetings, when more diplomacy is used, without distorting the cost picture.

The approach to employees is, of course, entirely different. Here the pain and suffering are stressed, while the cost angle is completely eliminated. When accident costs are stressed to employees, cynicism inevitably results. Neither do we use ridicule, or any attitude that could possibly cause mass resentment. We tend to use the shock or scare treatment, which, although classified as the negative approach by some authorities, leaves an exceptionally good impression in the loggers' minds.

All visual methods are used at frequent safety meetings at camp level. Motion pictures, of course, are in demand and we limit that fare strictly to shorts on safety subjects. Due to a marked paucity of woods safety films, LSA has its own motion-picture department, which produces three or four 10-minute, sound, color movies each year.

A change of pace in visual presentations maintains interest, and we alternate movies and slides with high-pressure card presentations. A typical presentation is to persuade the men to accept hard hats. Since most loggers are ardent sports fans, the presentation opens up with a short discussion of the relative risks in the boxing and wrestling games. Emphasis is on the head injuries suffered by boxers and, at this point, the safety man tosses a boxing glove down to the audience and asks them to examine it. Surprisingly enough, few sports fans have handled a boxing glove and little realize that this relatively soft glove can kill or maim a man.

Then, in simple terms, the functions of the brain and the scant protection afforded by the skull are explained. (Incidentally, we thought of providing a plastic skull at this point, but discarded the idea as too gruesome. Even we realize some limit to the so-called negative approach.)

Then illustrations of several types of disability caused by a brain injury are discussed. By this time, the audience is quite interested and has been able to follow the discourse. Then comes the difficult task of explaining the relationship between the weight of a falling object and the distance of fall. The artist has rather cleverly shown a falling branch picking up energy and turning into the effect of a 600-pound anvil. The presentation terminates with the men offered a choice in wearing a hard hat. If the men are still in doubt, they can be shown one of the movies on hard hats, in which are shown authentic scenes of a brain operation. That is what might well be termed the "clincher".

There are other LSA card presentations, one of which develops in a

Fig. 3.—This Rabelaisian type of cartoon, showing a pretty girl, accompanied an editorial dealing with impotence of some management in the promotion of accident control in their business.

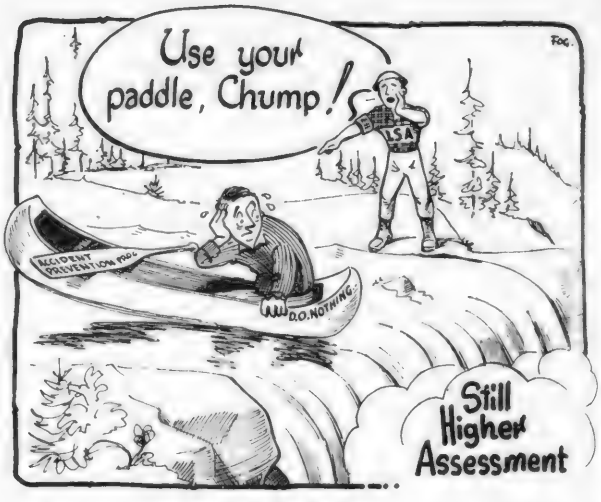

Fig. 4.—Another sketch portrays an indolent canoeist who is drifting towards disaster. Notice that the LSA does not hesistate to call dilatory management by the somewhat derogatory term "chump".

humorous vein the causes of accidents. Another deals with safety footwear.

The Lumbermen's Safety Association utilizes to the full a continuous poster campaign. These posters, by means of color, design, and limited captions, command attention.

It has been indicated in some degree how LSA tries to sell accident prevention to top management and to the workmen. There is still the most important link between these two groups. Maximum effort must be concentrated on the supervision at foreman level, for unless the foremen are completely sold, the best accident control program will founder.

LSA in common with other safety men, has spent considerable thought on how to dissolve that barrier of disdain, cynicism and scepticism that is an aura around many foremen. It has been found that one of the best methods is to establish discussion groups under a trained leader. A series of four or five one-hour planned discussions, such as the Lateiner system, will establish aggressive enthusiasm in place of indifference. Such discussions lead the supervision to freely commit themselves to be directly responsible for accident control. Although we have only commenced the system, we can already see the excellent results. Supervision is the most important cog in the accident control program. Once converted, encouraged and commended, the supervisor becomes a zealot of safety.

LSA strongly urges the full use of hard hats, of course, safety boots, safety vests (for river work) and, above all, the safety committee and incentives.

However, these essential pieces of safety equipment and methods are used to best advantage when all phases of the logging group have developed a state of mind that accepts accident control as part of the job.

Without a full appreciation of the mental attitude that resists change, however illogical that resistance may be, an accident control program is a long, tough haul against the grade.

Accident control is basically a selling job, and it involves selling what, to many of the unconverted, is an intangible. It requires modern selling techniques conducted with enthusiasm, conviction, and a rapid change of pace. To save human life, to limit pain, suffering and crippling, any means is justifiable in eliminating the bravado that for so long has bedevilled the logging industry.

Discussion

Vincent Ross (Draper Corp.): Can you expand a little on the 4-to-1 cost ratio in connection with accidents?

Mr. Reeves: This ratio indicates that for every dollar in direct costs, including first aid and workmen's compensation in connection with an accident, there will be $4 additional indirect cost to the employer. These indirect costs include loss and/or spoilage of production, training a replacement worker, time lost by supervisory personnel, damaged equipment, and many others. Not included in this calculation is loss to the worker of wages due to the accident. This ratio was derived from a careful study by W. Heinrich of the Travellers Insurance Co. of the costs of over 18,000 accidents, in several different industries, including logging.

Don McRae (Connor Lumber and Land Co.): I am very much interested in your mention of safety films made by your Association. Can you tell us a little more about your production methods and whether or not these films are available for use in the U.S.?

Mr. Reeves: Our Association first inquired about having such films produced by commercial movie studios. We found that their cost would be about $1,000 a minute, which we considered to be too high. Consequently, we tried producing them ourselves. We prepare a rough script and enlist the cooperation of one of our member companies in providing the locale and much of the acting talent. We hire a photographer, and one of our field representatives usually doubles as the leading actor. All films are done in color. We usually shoot five times or more the amount of film that we will finally use. Following the development of this film, we cut and edit it ourselves, and write a commentary to go along with the edited version. At first we tried hiring a professional commentator to make the sound track, but experience has proved that our own field men are the best commentators. We engage a sound studio to provide the sound track, including incidental music. Generally, total cost of these films has been less than $100 a minute, based on the final 7 to 10 minute print.

Prints of these films are available for sale to interested associations and companies in the U.S. Several of them have already been sold here, as well as in other provinces in Canada, New Zealand, Great Britain, and other countries. We prefer not to loan or rent them across the border because of difficulties and delays in the customs offices. Prints of each film are priced at around $100.

Color Control in Wood Finishing[1]

W. E. MARTIN

Technical Service Director, Grand Rapids Varnish Corp., Grand Rapids, Mich.

The two major problems in color control are: maintaining uniformity in the initial production color, and correcting changes that occur at later stages. To help determine the answers, the causes of variation are discussed.

IN A POLL taken some months ago, furniture manufacturers rated color control as their number one finishing problem. They stressed the need of maintaining uniform color from one production cutting to another. There are also problems of color uniformity from day to day and from piece to piece in the same cutting.

The purpose of this paper is to analyze the factors that cause color variation, and discuss methods of control that have been found useful.

The problem of controlling color may be divided into two parts: First, how to maintain uniformity in the initial production color, and second, what to do about color changes that take place later.

Control of the initial production color involves the following requirements:

a) That the finishing materials used be uniform in color and performance.
b) That application be uniform, particularly in the amounts applied or retained.
c) That the wood be reasonably uniform in its natural color; or if there are strong variations that they must be compensated by some procedure to equalize the color.
d) That the wood must have reasonable uniformity in surface condition.
e) That suitable inspection procedures be maintained to assure control of color at each stage of color application.

Control of Finishing Material

Control of finishing material is, of course, primarily the responsibility of the supplier. Certainly every reliable finish manufacturer strives to deliver materials that are uniform in color and performance. In spite of this, faulty or off-color material can sometimes be delivered. It is only a sensible precaution for the user to examine finishing materials in some manner before they go on the line in volume production. Such testing need not be elaborate or time consuming. It must, however, be done carefully and systematically. In particular, the color standards to which new shipments are compared must be carefully maintained and must be replaced occasionally. Otherwise, control testing may become only a source of misunderstanding. Suggested procedures are outlined in a bulletin entitled "Control Testing of Wood Finishing Materials" published by the Scientific Section, National Paint Varnish and Lacquer Association. This bulletin is at present in process of being revised and improved. Copies may be obtained from most finish suppliers or from the National Association.

Control of Application

With any transparent or partially transparent coloring material, the color produced depends on the amount applied, or the amount retained; and also to some degree on the wetness of application. For examination of this problem, materials should be considered in two groups; the sprayed materials and the wiped materials.

For materials applied by spraying and not wiped or blended, the amount applied and the color produced depend on two factors:

1. The equipment and its adjustment. The variables that control the amount of material delivered are: fluid pressure, size and length of fluid hose, fluid tip, and fan adjustment. The atomizing pressure affects the wetness of application and therefore the penetration and resulting color.
2. Operator technique. The important variables here are: speed of motion, closeness of lap, distance of gun from work, and triggering of the gun (partial opening as against full opening).

Professional trainers in spraying teach that the spray gun should be operated at full open trigger, and at a moderate and comfortable rate of gun movement; that the gun should be held uniformly 8 to 12 inches from the surface; that the fan should be wide open except for spraying narrow surfaces; and that lapping of strokes should be one-half the fan width. Fluid pressure and air pressure should be adjusted to produce a coating of the desired wetness at these conditions. The material should be so adjusted for strength that a full coat will produce the desired depth or amount of color. Do not expect operators to produce uniform results if the material is too strong, which requires a controlled partial application to produce the right color; or too weak, which requires repeated passes to build up the desired color.

Sometimes it is better to use two coats of a given coloring material. In this case, adjust the color strength or hiding of the material so that two normal coats will produce the required color.

To assist in holding color of a new cutting as compared to previous cuttings, these factors which affect amount should be watched: Use the same equipment, or at least the same type of equipment; the same spray gun, with the same size fluid tip and needle; the same length of fluid hose. Record the fluid and air pressure used and go back to them. Better still, when a color is running right, measure the amount of material that is being delivered per minute through the gun. Keep a record of it, and the next time you go back to that material, adjust the equipment to deliver the same amount.

Controlling the operator is not so easy to describe, but this much is true: an operator who is properly trained finds that the right way to spray is the easiest way, and he understands why control of his procedure is essential. Unless he is altogether irresponsible, he prefers to turn out good work rather than bad, and he will cooperate in doing it. Spray training for supervisors or operators is available in courses put on by the leading manufacturers of spray equipment. It is very much worthwhile, not only in control-

[1] Presented at Session IV, Wood Finishing, of the Eleventh National Meeting of the FPRS, held June 23-28, in Buffalo, New York.

The Author: W. E. Martin received his degree in chemistry from Cornell University. He has had 33 years of experience in the finishing industry, 26 with the Grand Rapids Varnish Corp. He has held his present position for 13 years, and is primarily concerned with finishing problems of the wood furniture industry.

ling production, but in the saving of wasted material that generally results.

For materials that are wiped—such as wiping stains, glazes, and fillers—the amount retained is the important factor. These materials are normally applied in excess, and then the excess is wiped off. Best control of the amount deposited is obtained when a "clean wipe" is used without scrubbing. Obviously, the amount retained and the color produced will depend on these factors:

1. Smoothness of the surface. Material will be retained in low spots such as large or small pores, torn grain, end grain, and sand scratches or gouges. This will be true whether material is applied directly to wood or over a partially sealed surface in which these imperfections still remain. Therefore, the surface must have uniform smoothness from piece to piece and from cutting to cutting, but not necessarily perfect smoothness. Smoothness depends on the machining and sanding of the wood, and also on the build of any seal coat used underneath and on the sanding of that coat.

2. Tack or adhesiveness of the surface. A hard, slick surface will retain less color than a softer or slightly tacky surface, even though both are completely smooth. Therefore, the sealer underneath, if any, must be of the same type, and used in about the same amount, from cutting to cutting. It must be uniformly dry and the sanding must be uniform, not well and smoothly sanded in one case and scratched up in the next.

3. Wetness or stickiness of the wiping material. If the material is wet when wiped or if it is oily in character or even if it is dry but powdery, it will wipe away more cleanly than if it is sticky or dried to a firm deposit. The material must remain open and not sticky for a sufficient length of time to allow a clean wipe. Also, it must not contain solvents that bite into and resoften the sealcoat underneath. Obviously, this could depend on the composition of the wiping material, and it could also depend on the composition of the sealer underneath. Wiping characteristics of glazes and fillers can usually be adjusted by thinning, with slower or faster thinners used as required.

There are, of course, some finishes that depend for their color and appearance on a controlled distribution of the wiped material—for example a finish done with blended glaze, ranging from light to heavy on the different areas. In such finishes there is no substitute for experienced operators and close inspection as a means of color control.

Effect of Wood Surface Condition

The variations in wood surface condition that commonly cause trouble are of three sorts: raised fiber; gouges, torn out grain, sand scratches, and end grain; and differences in the size and frequency of pores.

Of these conditions, only raised fiber is likely to affect the color, or more accurately the transparency, of sprayed stains or toners. This surface fuzz may reappear on a perfectly sanded surface. Proper sizing before the final belt-sanding operation permits the surface fiber to be more cleanly cut and subdues subsequent lifting. The consensus of opinion is that glue sizing is the simplest and most effective sizing method. With or without sizing, some finishers resort to a final hand sanding with 8/0 silicon carbide paper just ahead of the staining operation to assure uniform color and clarity from the stain.

The second group of conditions above listed, that is, gouges, torn grain, sand scratches, and end grain areas, do not materially effect the color produced by sprayed stains or toners, but do show up in wiped applications of pigment stains, fillers, or glazes. Color particles are naturally held in these low spots or porous areas.

Obviously, the ideal condition would be to have woods carefully selected for uniformity in pore structure and grain characteristics, and to have them perfectly machined, sized, and sanded. These ideal objectives are usually not practical to obtain. Fortunately, there are other means of controlling the color problem caused by defects in surface. To illustrate by an example, suppose we are dealing with a small-pore wood such as maple or gum, or even poplar, and the finish wanted requires an undertone stain followed by sealer and wiping glaze. The stock must be used as it comes. The machining and sanding cannot be too fussy. There are some turnings with plenty of end grain, perhaps some small spindles with chatter marks or torn grain. It is not practical to get a perfect wood surface on which to finish. There are still at least two ways of getting a good, uniform color by using a proper system.

One way is to smooth up the surface with suitable finishing material. For example, apply a natural filler after staining and before sealing. This will have little or no effect on the color and will produce a smoother surface on which to wipe the glaze. Or apply extra heavy coatings of sealer and do an extra good sanding job, especially on the rougher areas. It is a little difficult to fill up depressions in this way, but it will help considerably.

Another way is to develop the color system so that most of the color is put on with sprayed stain or toner, with only a weak glaze. In other words, avoid strong contrast between the undertone stain color and the overtone glaze color.

These alternates obviously will not produce exactly the same effects as could be produced with, say, a bright undertone stain, a thin washcoat sealer, and a strongly contrasting glaze cleanly and carefully wiped. But the production output will certainly look better than smudgy, streaked jobs resulting from the use of a system that is too critical.

The third type of wood surface variation that can produce color trouble is size and frequency of pores. This is generally important only in those finishes of the so-called "Seafoam" type, where opaque pigmented undertones of light color are applied to the wood, and the grain is brought back with colored filler. Obviously, if the wood varies from a very fine pore structure in one case to a coarse and widely separated pore in another, there will be a difference of over-all color. Here again, such differences can be subdued by avoiding sharp contrast between the undertone color and the filler color.

Natural Wood Color

There are no transparent coloring materials which, if applied in uniform over-all coating to woods or unlike natural color, will completely "equalize" the color. Dark stains naturally equalize better than light stains. Water stains are generally a little better than NGR Stains. Semi-opaque or translucent pigment toners of low hiding value may take care of minor variations in the natural wood color, but strong variations will still show through unless corrective action is taken.

The operations of pre-staining, that is, "shading-in" of color on one area so that it will come closer to the adjoining or overall average color, are familiar to all experienced finishers. The points to be emphasized for any production operation are: that pre-staining must be kept as simple as possible; that it must be closely supervised to see that it is effectively done.

Some general guides can be mentioned. With fully transparent finishes, pre-staining can be only from the lighter areas to the darker or average color. Attempts to shade up darker streaks with pigments are likely to produce spots with a "painted" look. However, when the undertone color is produced with translucent pigment toners, it is possible to shade up the dark areas by slightly heavier application of the toner.

Efforts to use two or more sap stains, for example, to bring the redder and greener areas of cherry to some average color in the middle, are generally not successful, except for small-scale custom application.

The point of close supervision of pre-staining is important. There are many cases in which sap staining or trim staining are so poorly done that they have little value, and there is still a lot of corrective shading required later in the system. A minor amount of corrective shading with lacquer shading stain after the sealer or first topcoat is alright, but used in excess it gives poor appearance. Corrective shading in connection with the glazing operation is likely to take a good deal of time and requires considerable skill.

Use of Color Standards

Even with the best possible uniformity in finishing materials, in surface preparation, and in application techniques, good control of color cannot be expected unless frequent comparisons are made of production results with predetermined strandards, for each stage of color application. This comparison should be checked at the start of each work period and frequently thereafter. It is especially necessary to keep close watch late in the day when operator fatigue or carelessness is more likely to occur. It is of course highly essential at the start of a second or later cutting. It is standard practice in many high production shops to run several pieces on the line, not less than three or four and sometimes as many as twenty, in advance of each production cutting, to make sure the color is right.

Standards should be set up to show the correct color at each important stage of the color system. The most important points at which to check color are: the stain or toner color; the glaze color; and the shading or overtoning color.

The best color standards are complete pieces, but these may be awkward to store or handle. Dummy fronts are frequently used in case goods manufacture. Good sized panels are certainly better than no standards at all. For a small operation, a single color standard showing each stage of the finish in step-off application may be adequate.

Color control at each stage of the finish obviously involves numerous inspections, and opinions differ as to who should do the inspecting. For small operations, the finishing superintendent may be able to inspect. In larger production operations and for exacting finishes this is not likely to be effective. The responsibility for inspection should be assigned to a competent and independent supervisor or inspector. However inspection is handled, pieces not acceptable for color at any stage should be removed for correction at that stage. Correction after subsequent color applications is always more difficult and may be impossible.

Color standards should be kept in such a manner as to avoid soiling and direct or strong light exposure. A convenient method for panels or fronts is to provide with hooks and hang in a cabinet near the point of use.

It must be remembered that standards will change to some extent with age, regardless of how they are kept. To get around this it is necessary to set up new standards at regular intervals. The time will depend in part on the lightness or delicacy of the color involved. An average opinion obtained from finishing superintendents is that color standards should be changed at least every six months, preferably every three or four months. Some companies select new standards from each cutting. The new standards should be picked from a production run. The selection requires judgment. Allowance must be made for the probable change or drift in the old standards. A competent individual in authority, preferably someone responsible to or for the sales organization, should approve the new standards.

Importance of Lighting on Color Judgment

Colors change under different light sources. They change, for example, from window sunlight to incandescent bulbs to fluorescent tubes. When two pieces are done with the same materials, if they match in one light they will usually match in all lights. But if any change in materials or system is involved, marked differences may be seen under one lighting as compared to another. The best lighting condition for color inspection is north window sunlight. Fluorescent lamps of the "warm white" classification are usually liked best among commercial light sources.

Problems of Color Change

Mr. D. G. Lubeck, in a paper presented before the FPRS last year, discussed the causes of color change and described testing procedures for the prediction of such changes. To review this subject briefly, we must face the practical situation that nearly all wood finishes, especially the light colors, show some degree of color change with age. If the change is drastic, it may create a serious problem. While there is no practical means of holding absolute uniformity of color between pieces of different age, we can seek color systems that show a minimum amount of change.

In formulating a finish for best color stability these points must be remembered.

1. All woods change color with light exposure, some quite drastically, and some change quite fast even under conditions of subdued light exposure. With light-transparent finishes, this change is bound to show through. There is still rather little of practical value that we can do to prevent wood color change. We can of course cover it up with opaque finishes. Semi-transparent pigment toners with partial opacity help to some extent. We have noted that light finishes done with white or off-white fillers or pigment stains wiped into the wood surface will subdue or mask wood discoloration to a greater degree than the same amount of opacity applied as a sprayed translucent pigment toner. The best way to avoid trouble caused by wood is to understand how the various woods change and avoid finish colors which show drastic contrast from this source.

2. Change in stains. The situation with reference to stains is better. While none of the commonly used transparent stains are completely lightfast, some are considerably better than others. By selecting the best dyes, NGR stains or water stains can be produced with reasonably good lightfastness. Experience indicates they are quite satisfactory for the majority of combination systems in which the color is built up with stain, filler, and glaze, and are fully satisfactory for all except the most delicate colors. They are not fully satisfactory for systems in which all or practically all the color is derived from the stain alone. Such finishes may show serious fading in direct window sunlight. Some new dyes only recently available are much better. Tests show two or three times better permanence than the best present NGR colors, but their use is still limited by very high cost. For a high degree of lightfastness over a wide range of colors and at a reasonable cost, pigment colors must be used. By reducing them to very fine particle size and using them in low concentration transparent stain effects can be produced with excellent permanence. They do not have the same appearance value as transparent soluble dyes that are absorbed into the wood fiber, but for many finish effects they are satisfactory. There is a gradually increasing use of fine pigment dispersions in producing the lighter and more delicate colors wanted in furniture finishing.

3. Change in topcoats. Properly formulated nitrocellulose lacquers of the pale or water-white grades have

shown satisfactory color stability in service for the majority of wood finish colors, certainly for anything in the brown range, and even the light fruitwood colors. They have not been completely satisfactory for colors that are most sensitive to yellow discoloration, namely, white or off-white backgrounds, pale blues, and light grays. With these colors there have been occasional but persistent complaints of yellowing.

Since this is contradictory to what is expected from light-exposure testing of the lacquers involved, intensive studies have been made to determine conditions that cause yellowing. There are several. The serious after-effect of certain petroleum rubbing oils is now well known. Their use with delicate colors must be avoided. Exposure of finished pieces to certain chemical vapors, for example those given off by cold-cured rubber tires, causes violent discoloration. Yellowing is apparently induced in some cases by ingredients of filler or glaze diffusing slowly into the topcoat. Many water-white lacquer compositions discolor appreciably in total darkness, then bleach back on light exposure. All nitrocellulose compositions yellow quite rapidly at elevated temperatures—as little as 40 hours at 140° F. shows up in pale lacquers.

Formulations recently developed in pale or water-white nitrocellulose lacquers show improved resistance to all these factors, yet it must be admitted there still are problems with them. There are other topcoating materials available which show high resistance to yellowing under nearly all conditions. The two types that have shown most promise are urea synthetics and acetate lacquers. Selected formulations in both of these types show excellent color stability under light exposure, darkness exposure, heat exposure, and in contact with a variety of contaminants.

Summary

To summarize, color control in furniture finishing is no simple problem. The only way to achieve good control is to recognize and pay attention to all the many factors that cause color variation, from wood selection and preparation through every stage of color treatment. In particular, there must be effective inspection at every stage. Even though perfect control is maintained in production, there will still be some degree of color change with age. This change may be in the wood, in the stains or other colorants, or in the topcoat. Such changes can be minimized: 1) by understanding the color behavior of woods and selecting finishes accordingly; 2) by selecting all ingredients of the color system for best color stability; and 3) by using special topcoats that have maximum resistance to discoloration, particularly on finish colors that are most sensitive to yellowing.

Counting Methods in the Woodworking Industry

JOHN E. HYLER

VARIOUS ASPECTS OF COUNTING arise in the woodworking industry; many times it is important that an accurate count be obtained. In instances where relatively short pieces are being run, which can be piled crosswise on a truck or skid, piling can often be accomplished uniformly and in even courses after preliminary sizing has taken place. By piling material in even courses, it is a fairly simple matter to count the number of piece parts in a load.

In some cases, relatively short pieces that can be piled crosswise on a truck are not of such nature that they can be piled in even courses. An individual count may then be required on a piece-by-piece basis. In such an instance, it is difficult (or in many cases impossible) to make an accurate count, due to the disarray in which the material lies.

Lineal counting is an entirely different proposition, but one often required in woodworking, where lineal lengths of molding, trim, and other kinds of stock are produced. In various detail mills, where practically all lineal runs are quite short, responsibility often falls on the rip sawyer to make a manual lineal count on each order. An experienced rip sawyer soon learns to add together (mentally) 14-foot lengths, 12-foot, 10-foot or whatever, as he goes along.

Use Counting Machines

Obviously, however, where large lots of lineal stock are being run, it is a point in strategy to make use of a lineal counting machine as the material is processed through a ripsaw, molder, or some other lineal processing unit. Such counters are able to measure and keep count on lineal footage accurately, because they incorporate a measuring wheel that runs directly on top of the stock as it passes through the machine.

An instance of the use of such a machine is seen in Fig. 1. Here, the counting device is mounted at the rear, directly over the rear platen behind the lower cutterhead. Actually, such a device can be mounted at the front of a molder instead of the rear, and this is often done. Where a machine is equipped with a hopper feed, however, as the one here shown, it is much better to install the counter at the rear.

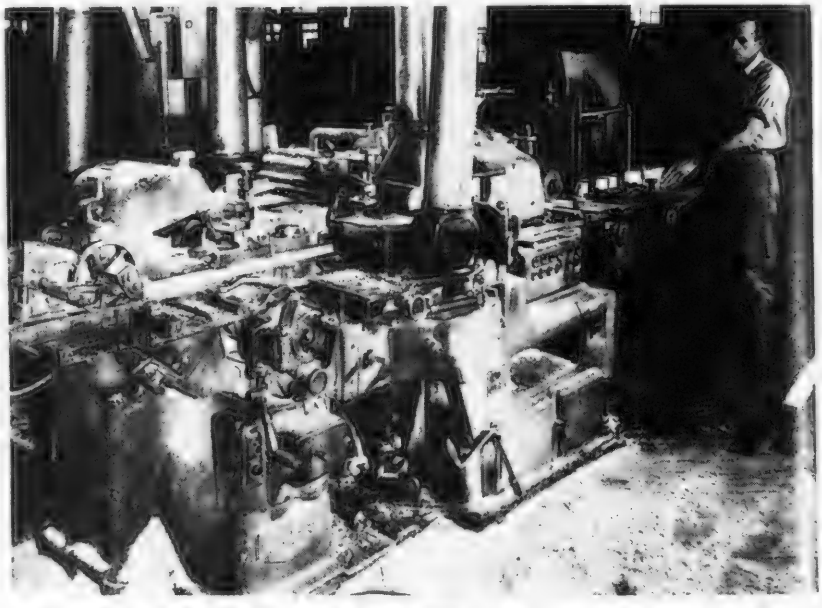

Fig. 1—An efficient, modern, molder, equipped with a counting machine at the re operating in the plant of Hallack & Howard Lumber Company, Denver, Colorado. Pho courtesy of Mattison Machine Works, Rockford, Illinois

Around the World in Forest Products Research and Development

Fourth FAO Wood Technology Conference to Be Held in Spain Soon

L. J. MARKWARDT

The fourth FAO Conference on Wood Technology will be held April 22–May 2, at Madrid, Spain, the Forestry Division of FAO announced recently.

L. J. Markwardt, Assistant Director of the U. S. Forest Products Laboratory, will again be a delegate officially representing the United States. Markwardt has attended all the previous conferences, and has contributed greatly to their success. He was chairman of the third conference, which was held in France in 1954.

The purpose of the conferences is to promote, in the engineering and mechanical fields of wood technology, the interchange of technical information and research findings, the unification as far as practicable of testing methods, and the development of improved practices relating to the utilization of the products of the world's forests.

Fire-retardent treatments and test methods for fire-resistance of wood and wood-base materials will receive special attention. Also to be discussed are recent developments in test methods for assessing the mechanical and physical properties of wood, the testing of fiberboards, particle boards, veneer, plywood and other glued constructions.

Other areas to be covered are the classification of wood-base materials, structural grading of timber, and developments in the sawing and machining of wood.

Scanning World Wide Forest Products Publications

Circular Ripsaws — What Clearance Angle? R. L. Cowling. C.S.I.R.O. Forest Products Newsletter. No. 237.

A test was made to determine what angle of clearance is sufficient and what most affects the clearance angle behind the cutting edges of saw teeth. The teeth of a 42-inch diameter circular saw were prepared so the angles of clearance varied. The teeth were painted with a quick drying lacquer to observe the points of wear when the saw was operated. Initially, the clearance angles tested ranged from 0° to 21°. Later, the smaller clearances were eliminated. Width of lacquer wear behind the cutting edges was measured as a method of assessing desirable clearance.

Twelve inch and 3 inch depths were sawn, and feeds faster than 94 feet per minute were obtained manually. Timbers sawn in the green state were messmate stringybark (Eucalyptus obliqua), Queensland grey ironbark (E. paniculata), and radiata pine (Pinus radiata). Maximum speeds in the three species were 350, 315, and 400 feet per minute respectively in the 3 inch depth of cut. Sawing in the 12 inch depth was restricted to messmate stringybark and to a maximum feed speed of 84 feet per minute.

The softwood appeared to require no greater clearance than the other timbers, and grey ironbark likewise appeared to require much the same clearance. Change in depth of cut appeared to have no influence on the clearance required.

Effect of increasing the feed speed was more noticeable for feeds between 42 and 160 feet per minute than for faster feeds, and was far more noticeable on teeth with 3° clearance than for greater clearance angles. Decrease in wear of lacquer between clearance angles of 3° and 6° was shown. Decrease in wear from 6° to 12° was much less. When the feed speed was increased to the maximum, all the lacquer on the top of teeth with 3° clearance was worn off, with relatively slight increase in wear for other clearance angles.

Lesser bulges in the wear occurred as a result of the bevel on the teeth. Position of the bulges marked the limit of engagement of the cutting edge, and did not mark the tooth bite. Bulges cannot occur if there is no bevel, as for a swage-set tooth. It is unlikely to occur for small bevel angles, and will disappear if the speed is sufficiently fast. The bulge was present for all clearance angles tested up to feed speeds of 84 feet per minute. Its length decreased with increase in clearance angle up to an angle of 21°.

A source of frictional loss was indicated by faint wear marks below the gullets. When well developed, this wear becomes a ring around the saw, approximately ½ inch wide, and outside the range of saw packing. It appears to be caused by sawdust forcibly expelled into the kerf. Wear on the front of each tooth is caused when the chip moves away from the side of set towards the kerf face on the opposite side. There appears little wrong with the shape of saw teeth or with the clearance usually adopted.

The Utilization of Bark. Part 1. Index to Bark Literature. J. E. Marian and A. Wissing. A report published by the Swedish Forest Products Research Laboratory, 1957.

Bark is a problem of waste, but it must be borne in mind that it is also a vast source of raw material. During the past years, aspects of waste bark utilization have been part of the research program of the Wood Technology Department of the Swedish Forest Products Research Laboratory. As part of the preparatory work, a large number of references to bark literature were collected. These are published in this report in its non-evaluated, non-abstracted form as an index to bark literature.

References used were a study of *Chemical Abstracts* from 1937 up to 1955, *Forestry Abstracts* from 1946–1947 to 1955, and *Chemisches Zentralblatt* for the years of World War II. In some cases, the literature has been followed up further back. The index contains only literature concerning waste bark utilization.

Categories covered in part 1 are: properties of bark; bark quantities; the collection of bark; the storing of bark; general reviews of the utilization of bark; the utilization of whole bark; the utilization of bark fibers; constitution and properties of tannins and tan extracts; isolation of phenolic substances (tannins) in bark extractives; the utilization of tannins; isolation and utilization of other substances (than tannins) in bark; and bark and water pollution.

Abstracts From Current World Literature

Glues and Gluing

ASTM. Seismic and shock loading; glued laminated and other constructions. ASTM, 1916 Race St., Philadelphia 3, Pa. 1957, 91 pages, $2.75

ASTM Special Technical Publication No. 209 combines two symposia presented at the Second Pacific Area Meeting in Sept. 1956. The first consists of four papers detailing the results of a research program to evaluate the strength, stiffness and rigidity of large wood diaphragms with different types of bracing and joints. The second symposium deals with glued laminated, stressed-skin and sandwich constructions. The book is illustrated with photos, diagrams and graphs and includes reports of discussion periods. [BRI Abstracts, Dec. 1957]

Northcott, P. L. The glueline-cleavage test applied to hardboard gluability. Composite Wood (India) 3, no. 5–6: 125–34 (Sept.–Nov., 1956).

In view of the growing trend toward surfacing hardboard with other materials, a method of testing the gluability of hardboard is needed. Experiments have been conducted to determine which is the more accurate test of this quality—a tension test (I) normal to the glueline or a glueline-cleavage test (II) in which a wedgelike block would be forced into the glueline. Results indicate the greater accuracy of (II) in recording bond quality. The cost and complexity of (I) are also greater than those of (II). [Bul. Pap. Chem. V. 28, No. 1]

Wood Chemistry

Isenberg, Irving H., Buchanan, Marion A., and Wise, Louis E. Extraneous components of American pulpwoods. Parts I and II. Paper Ind. 38, no. 11: 945–6; no. 12: 1042–6, 1098 (Feb., March, 1957); *cf.* B.I.P.C. 17: 157.

The extraneous components (I) characterize a specific wood, often far more sharply than do the cell-wall components. Color, odor, and taste of a wood are due to (I). Some of (I) prevent wood from being suitably pulped by the sulfite process; others give rise to digester corrosion in the kraft process. The distribution of (I) throughout the bole of a tree is far from uniform. At times, woods which are related botanically, or have very similar commercial uses, show differences in (I) that can be distinguished by means of simple color reactions. In the second part of the article, (I) are identified wherever possible and their properties and constants listed; 45 softwoods and hardwoods are covered. [Bul. Pap. Chem. V. 27, No. 12]

House Tests

ASTM. Full-scale tests on house structures. ASTM, 1916 Race St., Philadelphia 3, Pa. 1957, 64 p., $2.50.

ASTM Special Technical Publication No. 210 reports a symposium presented on full-scale testing of houses at ASTM's Second Pacific Area Meeting in Sept. 1956. Tests on houses built of plywood stressed-cover panels, on prefabricated military buildings, and on pre-cast multi-story flats are described in the papers reproduced, as well as Navy facilities for evaluating prefabricated buildings, and structural testing of a house under simulated wind and snow loads. Floor discussion of each paper is also included, and the book is well illustrated with photographs, charts, tables and drawings. [BRI Abstracts, Dec. 1957]

Utilization

Helge, Kjell. Utilization of sawdust as raw material for wallboard. Norsk Skogind. 11, no. 4: 124–30 (April, 1957). [In Norwegian; English summary]

Laboratory and mill-scale experiments were carried out at the Norwegian Pulp and Paper Research Institute on the mechanical refining of sawdust and wood shavings and on the possible utilization of sawdust as a raw material for the manufacture of fiber building boards. Defiberizing experiments in a P.F.I. laboratory mill showed that sawdust and shavings may differ in their suitability as raw materials for wallboard. The paper-forming properties were considerably improved by adding small quantities of sodium or calcium hydroxide immediately before fiberizing, whereby addition of lime resulted in better strength properties than did sodium hydroxide (compared at equal degrees of freeness). In the plant-scale experiments, sawdust was defibered by itself in a refiner with different grinding disks, together with coarse pulp from the screens in a refiner, and together with regular chips in an Asplund defibrator. Results indicated that up to 20% of the board-making material could be replaced by sawdust in any of these three methods without lowering the quality of the insulating board. The Asplund method did, however, give the best operation, whereas the other two methods caused mechanical difficulties. [Bul. Pap. Chem. V. 27, No. 11]

Marian, J. E., and Wissing, A. The utilization of bark. Part I. Index to bark literature. Svensk Papperstidn. 59, no. 21: 751–8; no. 22: 800–5; no. 23: 836–7 (Nov. 15–Dec. 15, 1956); 60, no. 2: 45–9; no. 3: 85–7; no. 4: 124–7; no. 5: 160–4; no. 7: 255–8; no. 9: 348–52; no. 11: 420–4; no. 14: 522–3 (Jan. 30–March 15, April 15, May 15, June 15, July 31, 1957). [In English]

The literature covering the period 1937–1955 on the utilization of bark is surveyed under the following headings: Properties of bark [anatomy, chemical composition]; Bark quantities; Collection of bark [general aspects of barking, mechanical barking (general reviews, cutting methods, friction methods, hydraulic methods), chemical debarking, separation of bark from wood chips]; Storing of bark; General reviews on the utilization of bark; Utilization of whole bark [bark as fuel (drying of bark, briquetting of bark and wood waste, burning of bark and wood waste), pyrolysis of bark, bark and wood waste as soil improvers, ingredients in adhesives and moldings]; Utilization of bark fibers [isolation and properties, hardboard and insulating board, paper and cardboard, textile fibers]; Constitution and properties of tannins and extracts [chemical constitution, physical properties (fluorescence, optical properties, electrical properties, rheology, surface, tension), effects on properties of other substances]; Isolation of phenolic substances (tannins) in bark extracts [fermentation, fractionation with ethanol, salting out, precipitation (with metal ions, with proteins and polyamides, with alkaloids, with other agents), adsorption and ion exchange, other methods]; Utilization of tannins [tanning material from waste bark, synthetic resins (adhesives, lacquers and varnishes, molding materials, ion-exchange resins), antioxidants, gas and oil purification, drilling muds and viscosity regulators, flotation agents, water treatment, dyes and mordants, other uses (cosmetics, medical preparations, microbicides and preservatives)]; Isolation and utilization of substances other than tannins in bark [carbohydrates; waxes, oils, resins, etc.; coloring matters; dihydroquercetin; alkaloids]; and Bark and water pollution. [Bul. Pap. Chem. V. 28, No. 1]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BRI ABSTRACTS OF BUILDING SCIENCE PUBLICATIONS, published for the use of its members, by the Building Research Institute, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, Washington 25, D. C. Over 70 periodicals are reviewed, plus new books and research reports from industrial, governmental, and academic laboratories and organizations.

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Review of FPRS Section Meeting Papers

Particle Board in the Building Field

Wayne C. Lewis, U. S. Forest Products Lab., Madison, Wis. Presented at the FPRS Mid-West Section Meeting, Nov. 14–15, 1957, at Milwaukee, Wis.

PARTICLE BOARD AS AN INDUSTRY in the United States began at the end of the Second World War. Originally, all particle board processes were based on the use of leftovers from other types of manufacturing. Plants were small, and used waste in the locality where it was produced. The largest use for particle board at this time was as corestock for furniture. As plants became larger, sales extended beyond the area where the board was produced. Decoratively faced boards were first used in building as paneling.

Productive capacity has increased to the point where markets beyond corestock for furniture are necessary. If plants producing high-density, thin boards are included, there have been 65 plants built in the United States. Production in 1956 is estimated at 570 million square feet on a 3/8-inch basis. Capacity at present is in excess of 1 billion square feet. Furniture core, lumber, and plywood have been estimated at about 500 million square feet. Productive capacity is such that more and more of the production of particle board must be used elsewhere than in furniture. Building construction is a natural area in which to use particle board because of volume use. The volume of other materials used in building is: lumber, 22 billion square feet (2/3 used in construction); softwood plywood, 5.6 billion square feet; insulation board, 3 billion square feet; and hardboard, 1.5 billion square feet.

At the present time, FHA accepts the use of standard grade particle board for use as floor underlayment on wood-frame subflooring above ground level; as corestock for sink and cabinet top core material; and as a core material for wardrobe and cabinet doors. Other uses of particle board generally accepted are for decorative paneling; sliding and cabinet door stock; hardpressed particle board for uses similar to those for hardboards (cabinet backs, drawer bottoms, dust dividers); and for solid-core doors.

Proposed and prospective uses are dependent on how well particle board can meet durability requirements for average interior exposures; severe interior exposures, particularly above concrete slabs, in bathrooms and other high-moisture areas; and for exterior areas or their equivalent. The influence of resin binders such as urea resins, phenolic resins, and new blends and combinations of resins is also important to the development of new uses.

Uses for particle board that are prospective are: as flooring underlayment on concrete slabs; wall sheathing; roof sheathing; soffit lining; subflooring; general panel material for interiors and exteriors; finish flooring; stressed-panel covers; exterior finish; and as concrete-form boards.

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Peter Cooper Corps., Gowanda
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Oval Wood Dish Corp., Tupper Lake
Pierce & Stevens Chemical Corp., Buffalo
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., Brewster
The Upson Co., Lockport

OHIO
American Machine & Foundry Co., Shelby
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati

OREGON
Brooks-Scanlon, Inc., Bend
Cascades Plywood Corporation, Lebanon
Conroy Publishing Corp., Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Kennametal, Inc., Latrobe
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley
Poinsett Lumber & Mfg. Co., Pickens

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

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Southern Pine Lumber Co., Diboll

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WASHINGTON
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Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
International Paper Co., Long-Bell Division, Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

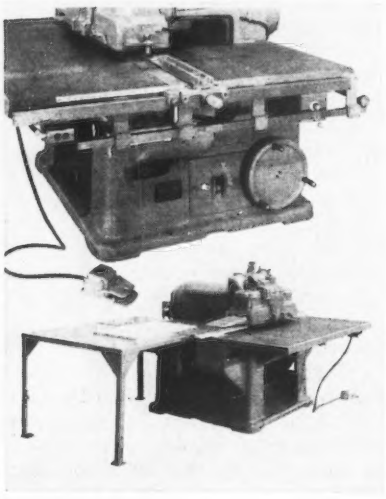
WISCONSIN
Harnischfeger Corp., Port Washington
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co., Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE



Random Width Lay-up Gage

A panel lay-up gage for random widths ripped from previously cut stock has been developed by Mattison Machine Works, for application with their No. 202 Straightline Rip Saw. The unit can be operated at either the right or left hand side of the saw blade, and can be operated either manually or by remote control through a foot switch and air cylinder.

An auxiliary lay-up table can be provided with an adjustable stop from which to start panels of predetermined width. The first ripping is placed against the stop, and the following rips are then placed in order until the layup is within five inches or less of making a complete panel. The panel lay-up gage is then actuated to set the front rip gage to the exact width required to complete the panel.

Teco Portable Loading Ramp

A new design for a portable loading ramp has been prepared by the Timber Engineering Co., for the speed-up of unloading lumber stocks from freight cars where the lumber dealer has access to a siding but whose yard facilities for a permanent ramp are limited.

The ramp has a standard height of four ft. and is 35 ft. 9 in. in length when completely assembled. Made of wood, the ramp assembles in three sections and is designed for use by either three or four-wheel equipment. Maximum total load is 15,000 pounds.

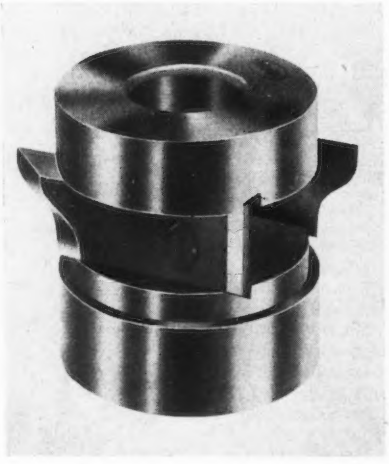
Copies of the portable ramp design No. 678 are available to lumber dealers and designers from Timber Engineering Co., 1319 18th St., N. W. Wash. 6, D. C.

Saw Chain Maintenance Guide

A new saw chain trouble shooting guide has been published by Borg–Warner's Atkins Saw Division. The 20-page manual contains practical tips on how to keep saw, chain, bars, and sprockets in top working condition. Part I deals with preventive maintenance. Causes of chain damage are covered in Part II. Part III illustrates the do's and don'ts of chain filing. Copies of the guide are available from Atkins Saw Division, Borg–Warner Co., Indianapolis 9, Ind.

Lumber Flow Booklet

"Engineering Layouts on Lumber Flow" is the title of a new booklet designed to show how to reduce costs and get more board feet of lumber per man-hour. Copies are available free while the supply lasts from the Moore Dry Kiln Co., P. O. Box 4248, Jacksonville 1, Fla.



Three Types of Shaper Collars

A complete line of shaper collars, including the solid, ball-bearing and notched types, are being produced by Wisconsin Knife Works, Beloit, Wis. Designed for parallel grooves of equal depth and set equidistant from the bore, the solid collars are usually used where cuts are not too deep and spindle speeds will be less than 4,000 rpm.

The ball-bearing collar is designed for high spindle speeds that require use of form or template. It has a prelubricated ball-bearing unit in the bottom collar, with alloy steel wear collar to protect the outer race. The notched shaper collar is for operations that require deep cuts, wide heavy knives, and spindle speed over 4,000 rpm. More information is available from the manufacturer at Dept. WP, Box 309.

NEW PUBLICATIONS

Silvical Characteristics of Scarlet Oak. Robert A. Campbell. Station Paper No. 86, available from the Southeastern Forest Experiment Station, Asheville, N. C.

Heavy Losses in Air Seasoning Georgia Pine and how to reduce them. R. H. Page and R. M. Carter. Station Paper No. 85, available from the Southeastern Forest Experiment Station, Asheville, N. C.

An Appraisal of Methods for Salvaging Small-Sawmill Residues in the Southeast. A. S. Todd, Jr., and W. C. Anderson. Station Paper No. 84, available from the Southeastern Forest Experiment Station, Asheville, N. C.

A guide to the Coweeta Hydrologic Laboratory. R. E. Dils. An account of the Coweeta Laboratory, where the affect of forests and forestry practices on water yields, water quality and streamflow are studied. Available from the Southeastern Forest Experiment Station, Asheville, N. C.

Resurvey of Christmas Tree Marketing in Michigan. L. M. James. Special Bulletin 419, available from Michigan State University Agricultural Experiment Station, East Lansing, Mich.

Note: The following publications are available free of charge from the Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Ottawa, Ontario, Canada.

Effects of Moisture Content on Strength and Use of Nailed Wooden Boxes. C. H. Nethercote. Reprint from Lumber Dealer & Buyer.

Strength and Related Properties of Woods Grown in Canada. Contains basic data accumulated over the years on properties of commercial wood species. F. P. L. Technical Note No. 3.

Wood Residues as Pulp Material and Developments in Wallboard Produution. J. A. Doyle and F. Bender. This report relates Canadian wood residue utilization to the production of various pulps and wallboards. F. P. L. Technical Note No. 6.

Effect of Tree Size of Spruce and Balsam Fir on Harvesting and Conversion to Lumber in Nova Scotia. J. A. Doyle. Study procedures planned to provide an accurate record of the man-time required for various operations from standing tree to rough lumber are discussed. FPL. Technical Note No. 5.

A Report — Chain-Flail Barkers and Slabwood Concentration Yards. G. E. Bell. Reprint from Timber of Canada.

How to Glue Pre-Treated Laminating Stock. P. L. Northcott. Reprint from Canada Lumberman. Available from the Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Vancouver, B. C., Can.

Timber Volume Depends on D²H. J. H. G. Smith and J. W. Ker. Reprint from the British Columbia Lumberman. Available from the University of British Columbia, Forestry Dept., Vancouver, B. C. Canada.

A Review of Utilization Practices in B. C. R. W. Wellwood. Reprint from British Columbia Lumberman. Available from the University of British Columbia, Forestry Dept., Vancouver, B. C. Canada.

Close Utilization Suggestions for the B. C. Interior. R. W. Wellwood. Reprint from British Columbia Lumberman. Available from the University of British Columbia, Forestry Dept. Vancouver, B. C. Canada.

Typical Lumber Designs. 1958 Edition. Lists over 300 typical designs of timber structures, from basic types of trussed rafters and heavy roof trusses to highway structures, towers, bridges, and farm buildings. Copies can be obtained from Timber Engineering Co., 1319 18th St., N. W., Washington 6, D. C.

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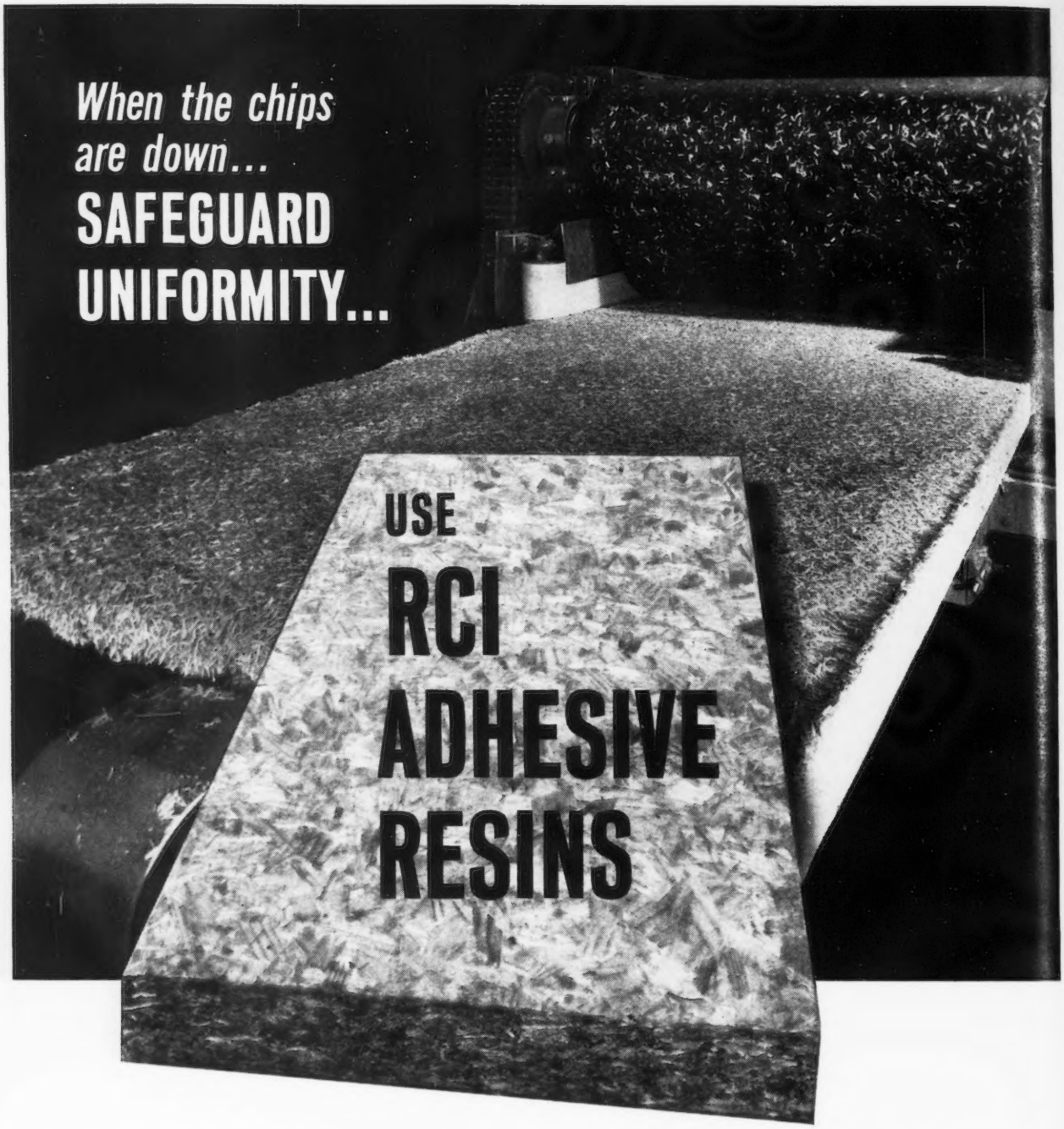

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